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VIA OVERNIGHT COURIER
AND ELECTRONIC DELIVERY

March 6, 2019

Bruce Rundell
Remedial Project Manager
U.S. EPA – Region III
3HS23
1650 Arch Street
Philadelphia, PA 19103

Reference: **Final Human Health Risk Evaluation of Potential Groundwater Discharge to Kanawha River;**
Fike/Artel Superfund Site

Dear Mr. Rundell,

On behalf of the Fike/Artel Site Trust (Trust), enclosed is the final Human Health Risk Evaluation of Potential Groundwater Discharge to Kanawha River. As directed by the United States Environmental Protection Agency (EPA) in correspondence dated February 20, 2019, the final memorandum was revised with consideration of EPAs October 16, 2018 comments and consistent the Trust's November 14, 2018 associated response letter.

Should you have any questions regarding this matter, please feel free to contact me or (b) (4) (b) (4)

Sincerely,
de maximis, inc.
(b) (4)

Project Coordinator

MHS/jr
Enclosure

cc: Bill Huggins – WVDEP (via FedEx and email, w/ attachment)
(b) (4)
Fike Trustees (via email, w/ attachment)

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Memorandum

Date: 6 March 2019

To: Bruce Rundell, USEPA Region 3
William Huggins, WVDEP

Copies to: (b) (4)
Bill Hyatt, K&L Gates

From: (b) (4) Geosyntec Consultants

Subject: Human Health Risk Evaluation of Potential Groundwater Discharge to Kanawha River, Revision 1, Fike/Artel Superfund Site, Nitro, West Virginia

INTRODUCTION

On behalf of the Fike/Artel Site Trust (the Trust), Geosyntec Consultants (Geosyntec) has prepared this revised memorandum to summarize an evaluation of potential human health risks posed by the potential discharge of groundwater chemicals of concern (COC) at the Fike/Artel Superfund Site (the Site) to the Kanawha River. The evaluation was performed in accordance with the *Work Plan – Human Health Risk Evaluation of Potential Groundwater Discharge to Kanawha River, Revision 1* (Work Plan; Geosyntec, 2018), with consideration of the United States Environmental Protection Agency's (USEPA's) comments dated 19 April 2018. This memorandum (Revision 1) includes updates to the original memorandum (dated 29 May 2018) to address comments received from USEPA and the West Virginia Department of Environmental Protection (WVDEP) on 16 October 2018 as outlined in the *Response to Comments Letter* (RTC Letter) dated 14 November 2018. The changes in the RTC Letter were accepted by USEPA and WVDEP in a letter dated 20 February 2019.

This evaluation was performed in response to a 19 December 2017 request from USEPA, which stemmed from the state of West Virginia's reclassification of the Kanawha River in the vicinity of the Site as a potential drinking water source. Specifically, West Virginia reclassified Zone 1 of the Kanawha River (between Diamond, WV and Point Pleasant, WV) as a "Category A" waterbody in 2015. This designates the Kanawha River as a potential drinking water source, although there are currently no withdrawals of surface water from the Kanawha River for consumptive use.

Potential groundwater discharge may occur directly to the Kanawha River, which is west of the Site, or indirectly via potential groundwater discharge to Armour Creek which then drains into the Kanawha River approximately 2 miles northeast of the Site. The location of the Site relative to the Kanawha River and Armour Creek is shown in **Figure 1**. This revised memorandum presents an evaluation of potential human health risk associated with exposure to the 22 Site COCs in drinking water obtained from Kanawha River, considering both the potential direct and indirect groundwater discharge scenarios. As documented below, the evaluation indicates that there are no unacceptable human health risks associated with potential direct or indirect discharge of groundwater COCs to the Kanawha River.

KANAWHA RIVER EVALUATION

The risk evaluation associated with potential groundwater discharge directly to the Kanawha River included four main components: (i) selection of a focused near-river groundwater dataset that is most relevant for evaluating potential impacts to the Kanawha River; (ii) calculation of groundwater flux/discharge to the Kanawha River; (iii) evaluation of dilution/mixing in the Kanawha River; and (iv) comparison of relevant screening values to the near-river groundwater data set when accounting for dilution/mixing within the Kanawha River. Each of these steps is described in the subsections below.

Selection of a Near-River Dataset

As discussed in the Work Plan and USEPA-approved *Assessment of Groundwater-Surface Interaction* (Geosyntec, 2011), a focused near-river groundwater dataset is considered appropriate for evaluation of potential groundwater/surface water interaction. Groundwater concentrations close to the river for COCs present in contiguous plumes with the Fike/Artel Site tend to be lower than those observed near the Site proper due to a number of attenuation mechanisms, including the following:

- Intrinsic degradation of many volatile organic compounds (VOCs);
- Attenuation of metals, stemming from the recovery of aquifer geochemical conditions in groundwater just downgradient of the Site to background conditions; and
- Hydrodynamic dispersion (brought about by the bifurcation of COC plumes downgradient of the Site) and potential retardation of COCs.

Thus, COC concentrations in groundwater near the river are more representative of concentrations associated with a potential groundwater-to-surface water pathway. The attenuation mechanisms

discussed above are discussed further in the USEPA-approved *Groundwater Conceptual Site Model, 2016 Update* (2016 CSM Update; Geosyntec, 2016).

The development of a focused near-river dataset for each COC was performed in accordance with the Work Plan and followed the general data reduction approach employed in Geosyntec (2011). Groundwater data from 24 sample locations within 500 feet (ft) of the river were included (**Figure 2**). In addition, selected data beyond this 500-ft boundary were added to the dataset so that each COC was represented. Specifically, data from monitoring well MW-223I were included in the analysis to provide analytical data for the pesticides 4,4'-dichlorodiphenyltrichloroethane (4,4'-DDT) and aldrin. Consistent with the Work Plan, the latest data by location and COC were used for locations/sample intervals with more than one sample event. For metal COCs (i.e., arsenic, iron, and manganese), the dataset conservatively included the maximum of either total or dissolved concentrations when both data types were available. The focused near-river dataset is provided in **Table 1**, which also includes summary statistics (i.e., maximum, geometric mean) for each COC for use in subsequent steps.

Key observations based on a review of the focused near-river data set include the following:

- Each of the pesticide COCs was non-detect, consistent with their very limited distribution due to poor mobility in groundwater, as discussed in the 2016 CSM Update;
- Metal COCs were detected at most locations, consistent with their natural presence in soil and groundwater in the vicinity of the Site; further discussion of metal fate and transport is provided by Geosyntec (2006, 2016);
- Several COCs have right-skewed data distributions (i.e., qualitatively, multiple parameters have a single or a small number of elevated values with a large number of non-detects or low values);
- Several VOCs and semi-volatile organic compounds (SVOCs) were detected in less than 15% of the samples in the near-river data set, including (detection frequency in parentheses): 1,1,2-trichloroethane (1,1,2-TCA; 2%); carbon tetrachloride (5%); chlorobenzene (10%); tetrachloroethene (PCE; 2%); trichloroethene (TCE, 12%); and bis(2-chloroisopropyl) ether (13%); and
- Data for select VOCs were consistent with the potential for off-Site sources (i.e., unrelated to Site activities), consistent with the highly industrialized nature of the Kanawha Valley and as discussed in the 2016 CSM Update; examples include but are not limited to the following:

- Carbon tetrachloride was only detected at SB-30 to the northwest and at elevated concentrations (up to 2,650 micrograms per liter [µg/L]) while non-detect at all other near-river locations;
- Similarly, chloroform (CF) was detected at concentrations up to 986 µg/L at SB-30 but is either non-detect or, when detected, is less than 1 µg/L at all other near-river locations; and
- TCE detections were clustered in the northwest (FL-MW-3A, FL-MW-3B, SB-24, and SB-30); in addition, TCE is detected at significantly greater concentrations at FL-MW-3A (1,400 µg/L) than other locations (only 12 µg/L or less).

Similar conclusions can be drawn for other COCs (e.g., 1,1,2-TCA, benzene chlorobenzene, PCE, and vinyl chloride [VC]) from the near-river dataset and/or based on data presented in the 2016 CSM Update. Select data from the 2016 CSM Update are included in **Attachments A-3 and A-4** for reference.

Calculation of Groundwater Flux/Discharge

Calculation of potential groundwater flux/discharge along the Kanawha River was estimated following the approach outlined in the Work Plan. Specifically, discharge was estimated using the following equation:

$$Q = \frac{K \times (t \times L) \times i}{CF}$$

where:

- Q = groundwater flux/discharge (cubic feet per second [cfs]);
- K = hydraulic conductivity (ft/day);
- t = aquifer thickness (ft);
- L = length of potential discharge along the river (ft);
- i = hydraulic gradient (ft/ft); and
- CF = conversion factor (86,000 seconds/day).

Site-specific data were used as input parameters to estimate representative near-river hydraulic conductivity, area of potential discharge, and hydraulic gradient, as discussed below.

Hydraulic Conductivity

Hydraulic conductivity data for the Site are presented in Figure 8 of the 2016 CSM Update, which is included in **Attachment A-1** for reference. As discussed in the 2016 CSM Update, hydraulic conductivity testing indicates moderate but variable hydraulic conductivities in the alluvium, with higher conductivities generally observed northeast of the Site while lower hydraulic conductivities were observed elsewhere, specifically to the west in close proximity to the Kanawha River. Lower hydraulic conductivity measurements in the western portion of the Site are consistent with steeper hydraulic gradients typically observed in this area during potentiometric gauging. For reference, potentiometric maps from 2006 to 2015 reported in the 2016 CSM Update are included in **Attachment A-2**.

Three hydraulic conductivities measurements were performed within 500 ft of the Kanawha River, with a range from 0.58 to 18.4 ft/day with a geometric mean of 4.65 ft/day. This geometric mean was selected as the representative hydraulic conductivity value for use in the discharge/flux evaluation. Use of geometric means as a summary statistic for hydraulic conductivity is common given that conductivities are often log-normally distributed (Rehfeldt *et al*., 1992).

The three near-river hydraulic conductivity measurements were from wells screened in the "deep zone" of the aquifer. As discussed in the 2016 CSM Update, the alluvium generally coarsens downward from lower permeability materials (i.e., silt and clay) to higher permeability materials (sand and silt with limited gravel in the deepest horizon). In addition, cone penetrometer testing (CPT) during the pre-remedial design investigation (PRDI) in 2003 indicated extensive lower permeability material in the shallow aquifer zone along the river. This is consistent with overbank deposits, which is common in alluvial systems like the Kanawha Valley. Therefore, use of hydraulic conductivity values from the deep zone is conservative as it does not take into account the observed, lower permeability overbank formation that may hinder flow into the river.

Cross-Sectional Area of Potential Discharge

The area of discharge was calculated using the length of potential discharge along the river, L, multiplied by the estimated thickness of the alluvial aquifer near the river, t.

- L was conservatively estimated to be 3,750 ft, which is based on the approximate shoreline length of the 500 ft near-river buffer illustrated in **Figures 1 and 2**. This is a conservative estimate, as each COC is only distributed along the shoreline for a portion (and sometimes a small fraction) of this length. For example, the length of potential discharge for hexamethylphosphoramide (HMPA), the most widely distributed COC, is approximately 2,500 ft based on plume contours presented in Figure 13a of the 2016 CSM Update

(included in **Attachment A-3** for reference). Some COCs have substantially smaller plume lengths along the shoreline (see plume maps in **Attachment A-3**).

- *t* was estimated to be 35.8 ft (on average) based on historical lithology borings (i.e., depth to bedrock), ground surface elevations, and potentiometric data collected within 500 feet of the river bank. The basis for the aquifer thickness calculation is presented in **Table 2**.

Based on the above length and thickness, the cross-sectional area of potential discharge was conservatively estimated to be 134,250 square feet (ft^2).

Near-River Hydraulic Gradient

Near-river hydraulic gradients were estimated as described in the Work Plan. The estimate is summarized in **Table 3** and based on the following data sources:

- Water level elevations in near-river monitoring wells/piezometers from four gauging events from 2006 to 2015; for reference, potentiometric maps from the 2016 CSM Update are included in **Attachment A-2**;
- The pool elevation of the Kanawha River from the same date as the potentiometric data[1];
- Horizontal distances from near-river locations to the edge of the Kanawha River, as estimated in the geographic information system (GIS).

The average near-river hydraulic gradient was estimated at 0.027 ft/ft (**Table 3**). Use of the average gradient is appropriate because it accounts for potential seasonal and spatial variability.

Groundwater Flux/Discharge

Based on Site-specific data and assumptions related to near-river hydraulic conductivity, area of potential discharge, and hydraulic gradient, the groundwater flux/discharge was estimated using the approach outlined previously to be approximately 0.20 cubic feet per second (cfs). The details of the flux analysis are summarized in **Table 4**.

[1] Approximately 12 river miles downstream of the Site, the United States Army Corps of Engineers operates the Winfield Lock and Dam at a normal pool elevation of approximately 566 feet above mean sea level (ft msl). The pool elevation of the Kanawha River from the same date as the potentiometric data was obtained from the U.S. Geological Survey (USGS) Station Number 03198000 at Charleston, WV (http://waterdata.usgs.gov/wv/nwis/rt). This station is on the same pool of the Kanawha River as the Site.

Evaluation of Dilution/Mixing Zone

As discussed in the Work Plan, a dilution factor was developed to account for dilution/mixing of groundwater discharge with the Kanawha River. The dilution factor was developed by comparing the estimated groundwater discharge (0.20 cfs) to one-third of the Kanawha River harmonic mean flow. The harmonic mean flow used in this evaluation was 6,950 cfs based on USGS Station Number 03198000 in Charleston, WV[2]. Use of this station is conservative given that the Charleston, WV station is upstream of the Site. The factor of one-third is consistent with West Virginia mixing zone regulations provided in 47CSR2§5.2.e. A dilution factor of 11,583 was estimated based on the metrics above, as summarized in **Table 4**. The near-river geometric mean and maximum values for each COC were divided by the dilution factor for comparison to applicable screening criteria, as discussed in the following subsection.

Screening Criteria

Screening Process and Rationale

To evaluate the potential for human health risk stemming from groundwater-surface water interaction between the Site and the Kanawha River, Geosyntec screened near-river groundwater COC concentrations, accounting for dilution/mixing, with the following screening benchmarks (as available). This approach is consistent with the Work Plan, with consideration of USEPA's comments dated 19 April 2018.

- The Site's current groundwater Preliminary Remedial Goals (PRGs), which are based on an unrestricted domestic use scenario (including ingestion) and account for cumulative cancer risk and/or noncancer effects.
- USEPA's May 2018 Regional Screening Levels (RSLs; USEPA, 2018) for tapwater based on (i) a target cancer risk (TR)[3] of 1×10^{-6}, or (ii) a Site-specific target hazard quotient (THQ) for noncancer endpoints, developed to account for the potential cumulative effects of multiple COCs on the same target organ. Development of Site-specific THQs is discussed further below.

[2] https://streamstatsags.cr.usgs.gov/gagepages/html/03198000 htm
[3] Although the tapwater RSLs based on the cancer endpoint used in this evaluation are based on a TR of 1×10^{-6}, USEPA's acceptable risk ranges from 10^{-6} to 10^{-4}, as discussed in the National Contingency Plan (NCP), 40 CFR 300.430. Because the screening risk level is at the low end of the NCP target range, no adjustment is necessary for the cancer-based RSLs.

- West Virginia's Human Health Water Quality Criteria based on drinking water and fish consumption (47CSR2, Appendix E, Table 1).

The PRGs and West Virginia's Human Health Water Quality Criteria were used without adjustment. The adjustment of the default RSLs required three steps, as outlined below.

The first step is summarized in **Table 5**. Nine COCs were retained for target organ-specific adjustment based on the following criteria:

- The COC only has noncancer endpoints (HMPA, bis (2-chloroisopropyl) ether, chlorobenzene, iron, and manganese); or
- For the 15 COCs that have tapwater RSLs based on both cancer and noncancer endpoints, the COC was retained for evaluation of common target organs if its noncancer RSL at a THQ of 0.1 is lower than its cancer-based RSL at a TR of 1×10^{-6}. The retained COCs were 1,1,2-TCA, 1,2-dichloropropane (1,2-DCP), PCE, and TCE. For the other 11 COCs (i.e., those for which the cancer-based RSL is more than 10-times lower than the corresponding unadjusted noncancer-based RSL at a THQ of 1) this refinement step demonstrates that the noncancer-based RSLs (even after adjustment for common target organs) would not factor into the selection of the final screening criteria.

The second step involved listing the target organs for the retained COCs in a matrix to assess which COCs shared target organs (**Table 6**). A target organ adjustment factor for each COC was calculated from the maximum number of COCs sharing the same target organ (**Tables 6 and 7**). For example, three COCs share the respiratory system as a target organ, thereby resulting in a target organ adjustment factor of 0.33 for all COCs that affect that target organ.

The third step involved the calculation of the Site-specific noncancer tapwater RSLs by multiplying the RSLs based on a THQ of 1 by the target organ adjustment factors (**Table 7**). The lower of the tapwater RSLs based on a 1×10^{-6} target cancer risk or the Site-specific noncancer THQ based on shared target organs was selected for each COC, as summarized in **Table 8**.

Table 8 provides a summary of the three sets of screening levels for the 22 COCs. These screening criteria were compared to the focused, near-river groundwater dataset (when accounting for dilution/mixing), as discussed in the next subsection.

Screening Results and Discussion

As discussed above, summary statistics of the near-river dataset (i.e., geometric mean, maximum) were developed for each COC. These summary statistics were divided by the estimated dilution factor (i.e., 11,583) for comparison to the screening criteria (**Table 8**).

- Given the right-skewed data distributions observed for several parameters[4], near-river geometric mean values were computed and screened to evaluate the magnitude of central tendency of near-river concentrations with respect to screening values. As shown in **Table 8**, near-river geometric mean concentrations (when accounting for dilution/mixing) were below each of the respective screening values.
- In addition, the screening values were also compared to the maximum value of the near-river dataset. The use of maximum concentrations along the river is a conservative step for the following reasons:
    - The prevalence of low detection frequencies for several COCs along the river; and
    - The potential for off-Site sources (i.e., unrelated to Site activities), as discussed previously.

  When accounting for dilution/mixing, the maximum near-river values were also below each of the respective screening values.

Review of **Table 8** indicates that when screening against maximum near-river concentrations and accounting for dilution, carbon tetrachloride is closest of the 22 COCs to exceeding its respective minimum screening value (i.e., 0.23 µg/L vs. 0.25 µg/L, respectively). As referenced above, carbon tetrachloride is infrequently detected in the near-river dataset (5% detection frequency). Furthermore, it was only detected at one boring at elevated levels while non-detect elsewhere. The spatial distribution of carbon tetrachloride across the valley indicates sporadic detections (see Figure 14 of Geosyntec [2003], which is included in **Attachment B** for reference). Collectively, these data indicate an off-Site source for carbon tetrachloride.

Collectively, these comparisons indicate that there are no unacceptable human health risks associated with potential direct discharge of groundwater COCs to the Kanawha River.

[4] Qualitatively, multiple parameters have a single or a small number of elevated values with a large number of non-detects or low values.

ARMOUR CREEK EVALUATION

Armour Creek is northeast of the Site and generally flows to the north (**Figure 1**). Armour Creek is not subject to the state of West Virginia's reclassification of the Kanawha River as a potential drinking water source. This is acknowledged in USEPA's letter dated 15 March 2018. However, potential discharge of groundwater COCs to Armour Creek, which eventually drains into the Kanawha River northeast of the Site, could indirectly impact drinking water risks associated with the Kanawha River. Per USEPA's letters dated 15 March 2018 and 19 April 2018, Geosyntec evaluated the potential effects of mixing of Site-related groundwater COCs in Armour Creek on human health risk for drinking water obtained from the Kanawha River. This evaluation relied on existing surface water analytical data and consideration of dilution of Armour Creek into the Kanawha River.

Surface water samples were collected from seven locations in Armour Creek in December 2015 and March 2016. As discussed in the USEPA-approved *Work Plan for Groundwater CSM Update, Revision 1* (Geosyntec, 2015):

- Sample points included locations along the portions of the creek in which one would expect the greatest potential for impact; surface water sample locations are illustrated in Figure 13a in **Attachment A-3**;
- Samples were analyzed for HMPA, 1,3-dimethyl-2-thiourea (13DM2TU), and bis (2-chloroethyl) ether (BCEE), which are the three most prevalent SVOCs and which have the highest potential for transport from Site groundwater to the creek; and
- Analysis of other COCs was not warranted, given the distribution of other COCs at the Site; this is supported by the plume maps and COC distribution figures provided in **Attachments A-3 and A-4**.

As discussed in the 2016 CSM Update, of the three SVOCs analyzed, only low-level detections of HMPA (up to approximately 5 µg/L) were observed in the most downstream (i.e., northern) locations sampled in Armour Creek. Both BCEE and 13DM2TU were non-detect.

The Armour Creek evaluation considered the level of anticipated dilution/mixing of the creek into the Kanawha River. As discussed below, the anticipated dilution of Armour Creek into the Kanawha River is approximately 52,000-fold (over four orders of magnitude), based on comparison of the estimated harmonic mean flow of Armour Creek to one-third the harmonic mean flow of the Kanawha River. Data inputs to estimate dilution are summarized below:

- The harmonic mean flow of Armour Creek was not identified after a review of literature sources. Therefore, an estimated harmonic mean flow of Armour Creek was obtained from a WVDEP online GIS database[5], which indicated a harmonic mean flow of Armour Creek of 0.044 cfs at the confluence of the creek with the Kanawha River.
- The harmonic mean flow for the Kanawha River was assumed to be 6,950 cfs, as referenced above. One-third of this flow is approximately 2,317 cfs; the basis for use of one-third of the harmonic mean flow was also discussed previously.

One consideration for this evaluation includes mixing of HMPA from Armour Creek with COCs that are potentially in the Kanawha River through direct groundwater discharge and which affect the same target organ as HMPA. To account for potential cumulative effects in this scenario, the Site-specific tapwater RSL of 2.7 µg/L, as shown in **Table 8**, was selected as a conservative screening value in the Kanawha River. The Site-specific tapwater RSL is lower than the Site's current groundwater PRG for HMPA (8.6 µg/L), which represents a groundwater concentration protective of human health under a potable use scenario and considered cumulative risk effects. West Virginia does not have a Human Health Water Quality Criteria for HMPA.

Potential HMPA contributions to the river were estimated as follows:

- Approximately 0.048 µg/L in the river based on the maximum HMPA concentration in the near-river dataset (576 µg/L), direct discharge to the Kanawha River, and the 11,583-fold dilution (**Table 8**).
- Approximately 0.000096 µg/L in the river based on input from Armour Creek, when considering HMPA concentrations in Armour Creek (i.e., up to approximately 5 µg/L) and the 52,000-fold dilution.

The total contribution is approximately 0.048 µg/L, which is substantially below the 2.7 µg/L Site-specific screening level referenced above.

Based on the estimated 52,000-fold level of dilution, HMPA concentrations in Armour Creek would have to be in excess of approximately 138,000 µg/L to be greater than the Site-specific tapwater RSL (2.7 µg/L) in the Kanawha River. These levels are more than approximately 25,000 times higher than concentrations observed in Armour Creek and approximately 40 times higher than the maximum concentration of HMPA observed in Site-wide groundwater.

[5] http://tagis.dep.wv.gov/streamflow/

Collectively, each element of the above evaluation indicates that unacceptable human health risks are not anticipated for drinking water obtained from the Kanawha River following potential mixing of Site-related groundwater COCs in Armour Creek.

CONCLUSIONS

The Kanawha River is currently designated as a potential drinking water source. As such, USEPA requested on 19 December 2017 (and subsequent communications/comments referenced herein) for the Trust to evaluate potential human health risks posed by potential groundwater discharge of the 22 Site COCs, either directly to the Kanawha River or indirectly to Armour Creek, which then drains into the Kanawha River. The evaluation, as described in this revised memorandum, was performed in accordance with the Work Plan, considered USEPA comments dated 19 April 2018, and incorporated changes based on the RTC Letter (approved by USEPA/WVDEP in a letter dated 20 February 2019).

The Kanawha River evaluation included screening of near-river groundwater data, when accounting for dilution/mixing in the Kanawha River, to relevant, site-specific screening values considered protective of human health under a drinking water exposure scenario. Near-river concentrations (when accounting for dilution/mixing) were below each of the respective screening values. The Armour Creek evaluation relied on existing surface water analytical data to evaluate the potential effects of mixing of Site-related groundwater COCs in Armour Creek on human health risk for drinking water obtained from the Kanawha River. Only HMPA has been detected in surface water samples from Armour Creek; these HMPA detections, when accounting for dilution/mixing in Kanawha River, are also below relevant screening values for the Kanawha River.

The Kanawha River and Armour Creek evaluations employed a number of conservative assumptions, including the following:

- Consideration of maximum near-river groundwater results;
- Consideration of three sources of screening levels, using a conservative cancer screening range (1×10^{-6}) and a Site-specific adjustment for cumulative noncancer effects that assume that all COCs are co-located along the river; and
- A conservative hydraulic formulation which does not take into account the observed low permeability overbank formations that may hinder flow into the river.

Collectively, these evaluations indicate that there are no unacceptable human health risks under a drinking water exposure scenario associated with direct or indirect discharge of groundwater COCs to the Kanawha River.

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TABLES

Table 1
Near-River Data Set
Human Health Risk Evaluation of Potential Groundwater Discharge to Kanawha River
Fike/Artel Superfund Site, Nitro, WV

Location	Date	Top Depth (ft bgs)	Bottom Depth (ft bgs)	1,3-Dimethyl-2-Thiourea	bis(2-Chloroethyl) Ether	bis(2-Chloroisopropyl) Ether	bis(2-Ethylhexyl) Phthalate	Hexamethylphosphoramide	1,1,2-Trichloroethane	1,2-Dichloroethane	1,2-Dichloropropane	Benzene	Carbon Tetrachloride	Chlorobenzene	Chloroform	Tetrachloroethene	Trichloroethene	Vinyl Chloride	4,4'-DDT	Aldrin	alpha-BHC	Heptachlor	Arsenic	Iron	Manganese
Geometric Mean Concentration Near the Kanawha River (µg/L) →				16	0.69	0.21	3.2	8.9	0.62	0.80	0.83	0.60	0.74	0.72	0.75	0.62	0.79	1.1	ND	ND	ND	ND	6.7	18,752	7,157
Max Detection Near the Kanawha River (µg/L) →				352	39	8.4	1,000	576	1.1	6.6	31	2.0	2,650	240	986	0.67	1,400	34	ND	ND	ND	ND	76	80,500	41,000
Detection Frequency →				15%	54%	13%	20%	73%	2%	37%	27%	22%	5%	10%	22%	2%	12%	27%	0%	0%	0%	0%	68%	100%	100%
Number of Detections Near the Kanawha River →				5	22	5	8	19	1	15	11	9	2	4	9	1	5	11	0	0	0	0	15	7	7
Number of Samples Near the Kanawha River →				33	41	40	40	26	41	41	41	41	41	41	41	41	41	41	1	1	5	5	22	7	7
CPT-5	17-Dec-00	30	40		5 U	5 U	5 U		2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	5 U					**8**	**6200**	**41000**
CPT-9	14-Dec-00	30	40		**35**	**8.4**	5 U		0.5 U	**0.87**	**2.4**	0.5 U	0.5 U	0.5 U	**0.31**	0.5 U	0.5 U	1 U					**23**	**80500**	**22200**
DPT-203	21-Jul-03	37	41	5 U	0.1 U	0.0505 U	0.378 U		0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					2.5 U		
DPT-203	21-Jul-03	56	60	5 U	**0.35**	0.0505 U	0.3775 U		0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					**6.3**		
DPT-204	07-Jul-03	34	38	5 U	5 U	**1.09**	**2.29**		0.5 U	**2.9**	**3.5**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					**7.9**		
DPT-204	08-Jul-03	41	45	5 U	**1.9**	**0.678**	0.3805 U		0.5 U	**3.8**	**2.6**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					2.5 U		
DPT-204	08-Jul-03	52	56			0.0535 U	0.4 U																**18.1**		
DPT-204	11-Dec-15	52	56	50 U	0.5 U			**3.6 J**	0.5 U	**1.4**	**0.764**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
DPT-221	02-Jul-03	37	41	5 U	0.1 U	0.0505 U	0.378 U		0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					**5.2**		
DPT-221	07-Jul-03	49	53	5 U	**2.5**	**0.158**	0.414 U		0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					**75.6**		
DPT-221	07-Jul-03	58	62	**150**	**1.5**	0.0487 U	0.365 U		0.85 U	0.85 U	0.85 U	0.85 U	0.85 U	0.85 U	0.85 U	0.85 U	0.85 U	**33**					**11.1**		
DPT-228	09-Jul-03	34	38	5 U	**0.63**	0.0555 U	0.415 U		0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					2.5 U		
DPT-228	14-Jul-03	46	50	5 U	0.1 U	0.0515 U	0.386 U		0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					**7.4**		
DPT-234	02-Oct-03	46	50	5 U	0.1 U	0.04745 U	0.356 U		0.5 U	**1**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					**10.7**		
DPT-234	02-Oct-03	54	58	5 U	0.1 U	0.04805 U	0.36 U		0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					**20.1**		
DPT-402	21-Jul-10	54	59					**6.23**																	
FL-MW-3A	02-Oct-03	25	35	5 U	**1.4**	0.04775 U	0.358 U		25 U	25 U	25 U	25 U	25 U	**240**	25 U	25 U	**1400**	25 U					2.5 U		
FL-MW-3B	02-Oct-03	46	61	10 U	**1**	0.0477 U	0.358 U		**1.1**	**2.1**	0.5 U	0.5 U	0.5 U	**1.2**	0.5 U	0.5 U	**12**	0.5 U					2.5 U		
GL-MW-15D	07-Oct-03	57	62	5 U	**0.21**	0.0481 U	0.3605 U		0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U					2.5 U		
MW-223I	26-Feb-04	31.5	41 5																0.00095 U	0.0004755 U	0.0004755 U	0.0004755 U	2.5 U	**376**	**6180**
MW-223I	07-Dec-07	31.5	41 5	11 U	**38.5**	**2.56**	2.745 U		0.5 U	**1.46**	**3**	**1.64**	0.5 U	0.5 U	**0.264**	0.5 U	0.5 U	**2.6**							
MW-223I	18-Jun-10	31.5	41 5					**1.37**																	
MW-422	09-Dec-15	51.58	56.58																		0.0255 U	0.0255 U	**8.8**	**79100**	**5450**
MW-422	25-Apr-17	51.58	56.58	**352**	1.1 U	2.745 U	27.45 U	**274**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**0.317 J**							
PBW-6	08-Dec-15	54	59																		0.0025 U	0.0025 U	**2.12**	**36000 J+**	**5890**
PBW-6	24-Apr-17	54	59	10 2 U	**0.148 J**	0.255 U	2.55 U	**4.69**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
PBW-7	08-Dec-15	47.5	53 5																		0.0263 U	0.0263 U	**10.4**	**37400**	**2960**
PBW-7	25-Apr-17	47.5	53 5	105 5 U	1.055 U	2.63 U	26.3 U	**297**	0.5 U	**0.338 J**	**0.282 J**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
PBW-8	08-Dec-15	57	62																		0.02575 U	0.02575 U	**10.3**	**40800**	**1800**
PBW-8	26-Apr-17	57	62	**271**	**37.6**	2.66 U	26.6 U	**576**	0.5 U	**6.63**	**30.5**	**0.977 J**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**12.8**							
SB-24	08-Dec-15	53	57	50 U	0.5 U			**5.44**	0.5 U	0.5 U	**0.264 J**	**0.323 J**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**25.9**							
SB-24-01	24-Oct-07	38	40	10.4 U	**1.74**	0.104 U	2.605 U	**0.397**	0.5 U	**0.459**	0.5 U	**0.617**	0.5 U	**19.1**	0.5 U	0.5 U	**8.83**	**34.3**							
SB-24-02	24-Oct-07	48	50	10.4 U	0.104 U	0.104 U	**4.43**	0.2605 U	0.5 U	0.5 U	0.5 U	**0.15**	0.5 U	0.5 U	0.5 U	0.5 U	**0.289**	0.5 U							
SB-30-01	04-Feb-08	38	40	61 U	0.61 U	0.61 U	**40.8**	1.525 U	0.5 U	0.5 U	0.5 U	**1.77**	**2650**	**0.373**	**986**	**0.667**	**1.1**	**0.485**							
SB-30-02	04-Feb-08	56.5	58 5	58 U	**0.686**	0.58 U	**1000**	**147**	0.5 U	**0.684**	0.5 U	0.5 U	**0.257**	0.5 U	**13.4**	0.5 U	0.5 U	0.5 U							
SB-31-01	04-Feb-08	38	40	23.55 U	0.2355 U	0.2355 U	**343**	0.59 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**0.951**	0.5 U	0.5 U	0.5 U							
SB-31-02	05-Feb-08	57	59	54 5 U	**9.33**	0.545 U	**854**	**5.46**	0.5 U	**0.316**	0.5 U	**0.303**	0.5 U	0.5 U	**0.323**	0.5 U	0.5 U	0.5 U							
SB-32-01	14-Sep-07	38	40		1.39 U	1.39 U	32.9 U	3.47 U	5 U	5 U	5 U	**2.04**	5 U	5 U	5 U	5 U	5 U	5 U							
SB-32-02	14-Sep-07	60	62		**0.235**	0.222 U	5.55 U	**175**	0.5 U	**0.84**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
SB-34-01	17-Jan-08	38	40	10 3 U	**1.17**	0.103 U	2.575 U	**6.91**	0.5 U	**0.328**	**0.721**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**0.714**							
SB-34-02	18-Jan-08	51	53	11.1 U	0.111 U	0.111 U	**4.17**	**31.2**	0.5 U	0.5 U	0.5 U	**0.139**	0.5 U	0.5 U	**0.141**	0.5 U	0.5 U	0.5 U							
SB-35-01	12-Sep-07	38	40		**1.49**	0.103 U	5.5 U	**10.3**	0.5 U	0.5 U	**1.04**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**1.59**							
SB-35-02	12-Sep-07	53	55		**0.468**	0.104 U	**6.3**	**36.6**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**5.76**							

Table 1
Near-River Data Set
Human Health Risk Evaluation of Potential Groundwater Discharge to Kanawha River
Fike/Artel Superfund Site, Nitro, WV

Location	Date	Top Depth (ft bgs)	Bottom Depth (ft bgs)	1,3-Dimethyl-2-Thiourea	bis(2-Chloroethyl) Ether	bis(2-Chloroisopropyl) Ether	bis(2-Ethylhexyl) Phthalate	Hexamethylphosphoramide	1,1,2-Trichloroethane	1,2-Dichloroethane	1,2-Dichloropropane	Benzene	Carbon Tetrachloride	Chlorobenzene	Chloroform	Tetrachloroethene	Trichloroethene	Vinyl Chloride	4,4'-DDT	Aldrin	alpha-BHC	Heptachlor	Arsenic	Iron	Manganese
Geometric Mean Concentration Near the Kanawha River (µg/L) →				16	0.69	0.21	3.2	8.9	0.62	0.80	0.83	0.60	0.74	0.72	0.75	0.62	0.79	1.1	ND	ND	ND	ND	6.7	18,752	7,157
Max Detection Near the Kanawha River (µg/L) →				352	39	8.4	1,000	576	1.1	6.6	31	2.0	2,650	240	986	0.67	1,400	34	ND	ND	ND	ND	76	80,500	41,000
Detection Frequency →				15%	54%	13%	20%	73%	2%	37%	27%	22%	5%	10%	22%	2%	12%	27%	0%	0%	0%	0%	68%	100%	100%
Number of Detections Near the Kanawha River →				5	22	5	8	19	1	15	11	9	2	4	9	1	5	11	0	0	0	0	15	7	7
Number of Samples Near the Kanawha River →				33	41	40	40	26	41	41	41	41	41	41	41	41	41	41	1	1	5	5	22	7	7
SB-37-01	11-Sep-07	38	40		0.16 U	0.16 U	7.8 U	0.4 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
SB-37-02	11-Sep-07	56	58		**3.02**	0.1085 U	6.1 U	**192**	0.5 U	**0.637**	**1.29**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**10.8**							
SB-38-01	22-Oct-07	38	40	11.35 U	0.1135 U	0.1135 U	2.84 U	0.284 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**0.393**	0.5 U	0.5 U	0.5 U							
SB-38-02	22-Oct-07	55	57	**33.2**	**0.166**	0.115 U	2.875 U	**88.3**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	**0.351**	0.5 U	0.5 U	0.5 U							
SB-39-01	22-Oct-07	38	40	11.65 U	0.1165 U	0.1165 U	2.905 U	0.2905 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							
SB-39-02	22-Oct-07	56	58	**13.9**	**0.195**	0.1125 U	2.81 U	**69.8**	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U							

Notes:
1. "Near the Kanawha River" includes 24 locations within 500 feet of the river plus MW-223I, which was included to provided analytical data for 4,4'-DDT and Aldrin.
2. ft bgs = feet below ground surface.
3. All results presented in µg/L.
4. Data presented reflects most recent analytical results by location, depth and/or chemical of concern (COC).
5. Geometric mean concentrations incorporate detections plus one-half the reporting limit for non-detects. For cases where all samples were non-detect, "ND" is reported.
6. Results for arsenic, iron, and manganese represent the maximum of total and dissolved concentrations, where applicable.
7. Qualifiers: J = estimated value; J+ = estimated with high bias; U = non-detect.
8. Bold values indicate a detection.
9. Blanks indicate that the parameter was not measured or, if measured, is not the most recent analytical result for that COC and location (see Note 4).
10. alpha-BHC = alpha-benzenehexachloride.
11. DDT = Dichlorodiphenyltrichloroethane.

Table 2
Estimated Near-River Aquifer Thickness
Human Health Risk Evaluation of Potential Groundwater Discharge to Kanawha River
Fike/Artel Superfund Site, Nitro, WV

Location	Ground Surface Elevation (ft)	Approximate Depth To Bedrock (ft bgs)	Estimated Bedrock Elevation (ft)	Approximate Potentiometric Elevation in December 2015 (ft)	Approximate Saturated Thickness (ft)
DPT-203/PZ-203	596.92	60	536.92	568.95	32.0
DPT-204/PZ-204	592.56	56	536.56	571.61	35.1
DPT-221/PZ-221	597.95	62	535.95	570.02	34.1
DPT-228/PZ-228	583.11	50	533.11	*570.5*	37.4
DPT-234/PZ-234	593.52	58	535.52	571.5	36.0
DPT-402	*597*	59	538	*571.25*	33.3
MW-422	592.98	56	536.98	568.89	31.9
PBW-6	597.55	59	538.55	*571.5*	33.0
PBW-7	586.83	50.5	536.33	571.18	34.8
PBW-8	597.79	62	535.79	*570*	34.2
SB-24 (2015)	*590*	57	533	*572*	39.0
SB-24 (2007)	*590*	50	540	*572*	32.0
SB-30	*590*	58.5	531.5	*571.75*	40.3
SB-31	*590*	59	531	*571.5*	40.5
SB-32	*590*	62	528	*571.25*	43.3
SB-34	*590*	53	537	*570.5*	33.5
SB-35	*590*	55	535	*570.25*	35.3
SB-37	*590*	58	532	*569.5*	37.5
SB-38	*590*	57	533	*568.9*	35.9
SB-39	*590*	58	532	*568.9*	36.9
				Average (ft)	**35.8**

Notes:
1. ft = feet.
2. ft bgs = feet below ground surface.
3. *Italics* indicates the value is approximated with use of nearby locations.

Table 3
Estimated Near-River Hydraulic Gradient
Human Health Risk Evaluation of Potential Groundwater Discharge to Kanawha River
Fike/Artel Superfund Site, Nitro, WV

Monitoring Well (MW) or Piezometer (PZ)	Estimated Distance from Kanawha River (ft)[1]	2015 Potentiometric Data			2011 Potentiometric Data			2010 Potentiometric Data			2006 Potentiometric Data		
		MW/PZ Water Elevation (ft)[2]	Approximate River Elevation (ft)[3]	Estimated Gradient (ft/ft)	MW/PZ Water Elevation (ft)[4]	Approximate River Elevation (ft)[3]	Estimated Gradient (ft/ft)	MW/PZ Water Elevation (ft)[5]	Approximate River Elevation (ft)[3]	Estimated Gradient (ft/ft)	MW/PZ Water Elevation (ft)[6]	Approximate River Elevation (ft)[3]	Estimated Gradient (ft/ft)
PZ-234	130	571.5	566.59	0.038	572.02	566.29	0.044	571.46	565.91	0.043	NM	566.57	NM
PBW-6	130	NM		NM	571.84		0.043	NM		NM	NM		NM
PBW-7	175	571.18		0.026	571.72		0.031	NM		NM	NM		NM
PZ-228	50	NM		NM	NM		NM	NM		NM	571.16		0.092
PZ-221	120	570.02		0.029	570.14		0.032	570.08		0.035	569.64		0.026
PBW-8	150	NM		NM	570.35		0.027	NM		NM	NM		NM
PZ-203	200	568.95		0.012	569.06		0.014	568.91		0.015	568.67		0.010
MW-422	110	568.89		0.021	568.71		0.022	NM		NM	NM		NM
PZ-204	500	571.61		0.010	571.78		0.011	571.78		0.012	571.48		0.010

Average from 2006 to 2015 (ft/ft)	0.027

Notes:

1. Distance from Kanawha River based on the horizontal distance from the well/piezometer to the shoreline, as estimated in GIS.
2. Water elevation in ft NGVD29, for period of record: December 15, 2015
3. Source for Kanawha River elevation (in ft NGVD29):http://waterdata.usgs.gov/wv/nwis
4. Water elevation in ft NGVD29, for period of record: September 11, 2011
5. Water elevation in ft NGVD29, for period of record: July 10, 2010
6. Water elevation in ft NGVD29, for period of record: February 6, 2006
7. NM = Not Measured
8. ft = feet
9. MW = monitoring well
10. PZ = piezometer

Table 4
Dilution Factor Calculation
Human Health Risk Evaluation of Potential Groundwater Discharge to Kanawha River
Fike/Artel Superfund Site, Nitro, WV

Parameter	Symbol	Unit	Value
Representative Near-River Hydraulic Conductivity	*K*	ft/d	4.65
Estimated Near-River Aquifer Thickness	*t*	ft	35.8
Conservative Length of Potential Discharge along Kanawha River	*L*	ft	3,750
Cross-Sectional Area of Potential Discharge	*A*	ft^2	134,250
Average Near-River Hydraulic Gradient	*i*	ft/ft	0.027
Conversion Factor	*CF*	s/d	86,400
Estimated Groundwater Flux/Dischrage[1]	*Q*	cfs	0.20
Harmonic Mean Flow of Kanawha River[2]	Q_{hm}	cfs	6,950
1/3 of the Harmonic Mean Kanawha River[3]	$1/3 \times Q_{hm}$	cfs	2,317
Estimated Dilution Factor[4]	*DF*	Unitless	11,583

Notes:

1. Groundwater flux/discharge was calculated by the following equation:

$$Q = \frac{K \times A \times i}{CF} \; where \; A = L \times t$$

2. Based on USGS Station Number 03198000 in Charleston, WV (https://streamstatsags.cr.usgs.gov/gagepages/html/03198000.htm)
3. The factor of one-third is consistent with West Virginia mixing zone regulations provided in 47CSR2§5.2.e.
4. Dilution Factor was calculated by:

$$DF = \frac{\frac{1}{3}Q_{hm}}{Q}$$

5. ft/d = feet per day
6. ft = feet
7. ft^2 = square feet
8. d/s = seconds per day
9. cfs = cubic feet per second

Table 5
Selection of COCs with Noncancer RSLs for Target Hazard Quotient Adjustment
Human Health Risk Evaluation of Potential Groundwater Discharge to Kanawha River
Fike/Artel Superfund Site, Nitro, WV

Constituent Class	COC	Tapwater RSL [1] (µg/L)			THQ = 0.1 < TR = 1E-6? [2]
		Cancer TR = 1E-06	Noncancer THQ = 1	Noncancer THQ = 0.1	
SVOC	Hexamethylphosphoramide	--	8	0.8	Yes
	1,3-Dimethyl-2-Thiourea [3]	--	--	--	--
	Bis (2-Chloroethyl) Ether	0.014	--	--	No
	Bis (2-Chloroisopropyl) Ether	--	710	71	Yes
	Bis (2-Ethylhexyl) Phthalate	5.6	400	40	No
VOC	1,1,2-Trichloroethane	0.28	0.41	0.041	Yes
	1,2-Dichloroethane	0.17	13	1.3	No
	1,2-Dichloropropane	0.85	8.2	0.82	Yes
	Benzene	0.46	33	3.3	No
	Carbon tetrachloride	0.46	49	4.9	No
	Chlorobenzene	--	78	7.8	Yes
	Chloroform	0.22	97	9.7	No
	Tetrachloroethene	11	41	4.1	Yes
	Trichloroethene	0.49	2.8	0.28	Yes
	Vinyl chloride	0.019	44	4.4	No
Pesticide	4,4'-DDT	0.23	10	1	No
	Aldrin	0.00092	0.6	0.06	No
	alpha-BHC	0.0072	97	9.7	No
	Heptachlor	0.0014	1.3	0.13	No
Metal	Arsenic	0.052	6	0.6	No
	Iron	--	14000	1400	Yes
	Manganese [4]	--	430	43	Yes

Notes:

[1] USEPA May 2018 Regional Screening Levels (RSLs) for tapwater based on: i) a target cancer risk of 1E-06, ii) a target hazard quotient of 1, and iii) a target hazard quotient of 0.1

[2] A "Yes" in this column indicates that the noncancer-based RSL at a target hazard of 0.1 is lower than the cancer-based RSL at a target cancer risk of 1E-6. These COCs were retained for the identification of shared target organs and the development of constituent-specific target organ adjustment factors to that will be used to calculate RSLs that are protective of cumulative effects from multiple COCs that affect the same target organ.

[3] USEPA November 2017 tapwater RSL table does not include 1,3-Dimethyl-2-Thiourea.

[4] The values correspond to the RSLs for "Manganese (Non-diet)."

Definitions:

µg/L = micrograms per liter
BHC = benzene hexachloride
COC = chemical of concern
DDT = dichlorodiphenyltrichloroethane
RSL = Regional Screening Level
SVOC = semi-volatile organic compound
THQ = target hazard quotient
TR = Target Risk
VOC = volatile organic compound

Table 6
Target Organ Matrix for Selected Noncarcinogenic COCs
Human Health Risk Evaluation of Potential Groundwater Discharge to Kanawha River
Fike/Artel Superfund Site, Nitro, WV

Constituent Class	COC [1]	Max # Shared COCs per Target Organ	Target Organ Adjustment Factor	Target Organs [2]													
				Liver	Blood	Immune	Kidney	Neuro	Thyroid	Repro	Cardio	GI	Resp	Develop	Ocular	Lymphatic	Whole Body
SVOC	Hexamethylphosphoramide	3	0.33										X				
	Bis (2-Chloroisopropyl) Ether	2	0.50		X												
VOC	1,1,2-Trichloroethane	3	0.33		X	X							X				X
	1,2-Dichloropropane	3	0.33										X				
	Chlorobenzene	1	1.0	X			X										
	Tetrachloroethene	2	0.50					X							X	X	
	Trichloroethene	2	0.50			X			X	X	X			X			
Metals	Iron	1	1.0									X					
	Manganese	2	0.50					X									

Notes:
[1] This table includes only the COCs for which the noncancer-based RSL at a target hazard of 0.1 is lower than the cancer-based RSL at a target cancer risk of 1E-6 (see Table 5).
Excluded COCs and the basis for exclusion are:
a) No noncancer RSLs: Bis (2-Chloroethyl) Ether
b) No RSLs: 1,3-Dimethyl-2-Thiourea
c) Cancer RSLs were lower than Noncancer RSLs at THQ=0.1: Bis (2-Ethylhexyl) Phthalate, 1,2-Dichloroethane, Benzene, Carbon tetrachloride, Chloroform, Vinyl chloride, 4,4'-DDT, Aldrin, alpha-BHC, Heptachlor, and Arsenic
[2] Target organs obtained from the Risk Assessment Information System (RAIS, https://rais.ornl.gov/tools/metadata.php) Chemical Toxicity Metadata for Chronic RfD and RfC Target Organs.

Definitions:
BHC = benzene hexachloride
COC = Constituent of Concern
DDT = dichlorodiphenyltrichloroethane
SL = Screening Level
SVOC = semi-volatile organic compound
VOC = volatile organic compound
RAIS = Risk Assessment Information System
RfC = reference concentration
RfD = reference dose
RSL = Regional Screening Level
THQ = Target hazard quotient

Table 7
Noncancer Tapwater RSLs Adjusted Based on Shared Target Organs
Human Health Risk Evaluation of Potential Groundwater Discharge to Kanawha River
Fike/Artel Superfund Site, Nitro, WV

Constituent Class	COC [1]	Noncancer Tapwater RSL THQ = 1 (µg/L)	Target Organ Adjustment Factor [2]	Target Organ Adjusted Noncancer Tapwater RSL (µg/L) [3]
SVOC	Hexamethylphosphoramide	8	0.33	2.67
	Bis (2-Chloroisopropyl) Ether	710	0.5	355
VOC	1,1,2-Trichloroethane	0.41	0.33	0.14
	1,2-Dichloropropane	8.2	0.33	2.73
	Chlorobenzene	78	1.0	78.0
	Tetrachloroethene	41	0.5	20.5
	Trichloroethene	2.8	0.5	1.4
Metals	Iron	14000	1.0	14000
	Manganese	430	0.5	215

Notes:

[1] This table includes only the COCs for which he noncancer-based RSL at a target hazard of 0.1 is lower than the cancer-based RSL at a target cancer risk of 1E-6 (Tables 5 and 6).

[2] The COC-specfic target organ adjustment factor is calculated by dividing a THQ of 1 by the maximum number of target organs shared with other the other COCs. See Table 7.

[3] Values derived in a Site-specific fashion to achieve a cumulative target hazard index of 1.0, accounting for contributions from multiple COCs that affect relevant target organs.

Definitions:

COC = Constituent of Concern
RSL = Regional Screening Level
SVOC = semi-volatile organic compound
VOC = volatile organic compound
THQ = Target hazard quotient

Table 8
Summary of Screening Criteria and Comparison to Near-River Groundwater Concentrations
Human Health Risk Evaluation of Potential Groundwater Discharge to Kanawha River
Fike/Artel Superfund Site, Nitro, WV

Constituent Class	COC	Site-Specific PRG [1]	Tapwater RSL Minimum of TR = 1E-6 and Target Organ Adjusted THQ [2]		WV Water Quality Standards [3]	Minimum Screening Level	Geometric Mean Concentration Near the Kanawha River		Max Detection Near the Kanawha River		Do Concentrations (Accounting for Dilution) Exceed Minimum Screening Level?
							Groundwater Concentration	Concentration Accounting for Dilution (Conc. ÷ 11,583)	Groundwater Concentration	Concentration Accounting for Dilution (Conc. ÷ 11,583)	
		(µg/L)	(µg/L)		(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
SVOC	Hexamethylphosphoramide	8.57	2.7	n	--	2.7	8.9	0.00077	576	0.050	No
	1,3-Dimethyl-2-Thiourea	218	--	--	--	218	16	0.0014	352	0.030	No
	Bis (2-Chloroethyl) Ether[4]	0.01	0.014	c	--	0.01	0.69	0.000060	39	0.0033	No
	Bis (2-Chloroisopropyl) Ether	1.4	355	n	--	1.4	0.21	0.000018	8.4	0.00073	No
	Bis (2-Ethylhexyl) Phthalate	2.2	5.6	c	--	2.2	3.2	0.00028	1000	0.086	No
VOC	1,1,2-Trichloroethane	1.1	0.14	n	--	0.14	0.62	0.000054	1.1	0.000095	No
	1,2-Dichloroethane	0.7	0.17	c	0.035	0.035	0.80	0.000069	6.6	0.00057	No
	1,2-Dichloropropane	1.6	0.85	c	--	0.85	0.83	0.000072	31	0.0026	No
	Benzene	0.4	0.46	c	0.66	0.4	0.60	0.000052	2.0	0.00018	No
	Carbon tetrachloride	0.5	0.46	c	0.25	0.25	0.74	0.000064	2650	0.23	No
	Chlorobenzene	1.8	78	n	680	1.8	0.72	0.000062	240	0.021	No
	Chloroform	1.1	0.22	c	5.7	0.22	0.75	0.000065	986	0.085	No
	Tetrachloroethene	0.3	11	c	0.8	0.3	0.62	0.000054	0.67	0.000058	No
	Trichloroethene	2.2	0.49	c	2.7	0.49	0.79	0.000068	1400	0.12	No
	Vinyl chloride	0.07	0.019	c	2.0	0.019	1.1	0.000097	34	0.0030	No
Pesticide	4,4'-DDT	0.005	0.23	c	0.000024	0.000024	ND	N/A	ND	N/A	N/A
	Aldrin	0.006	0.00092	c	0.000071	0.000071	ND	N/A	ND	N/A	N/A
	alpha-BHC	0.011	0.0072	c	0.0039	0.0039	ND	N/A	ND	N/A	N/A
	Heptachlor	0.013	0.0014	c	0.00021	0.00021	ND	N/A	ND	N/A	N/A
Metal	Arsenic	0.07	0.052	c	10	0.052	6.7	0.00058	76	0.0065	No
	Iron	600	14000	n	1500	600	18752	1.6	80500	6.9	No
	Manganese[5]	370	215	n	1000	215	7157	0.62	41000	3.5	No

Notes:

[1] Preliminary Remedial Goals (PRGs) established in the 2006 Amended Record of Decision. Values represent groundwater concentrations protective of human health under an uncontrolled potable use scenario and are based on a target cumulative excess cancer risk of 1E-4 and a maximum cumulative noncancer hazard index of 1 by target organ.

[2] Values provided in this column are the minimum of the EPA tapwater RSL based on a target excess lifetime cancer risk of 1E-6 (identified with a "c") and the tapwater RSL based on a site- and COC-specific target organ adjustment factor that accounts for the maximum number of share target organs among the COCs (identified with a "n") (see Table 7).

[3] WV Code of State Regulations Title 47, Series 2, Appendix E, Table 1. The criteria in this column have been calculated to protect human health from toxic and/or organoleptic effects through drinking water and fish consumption.

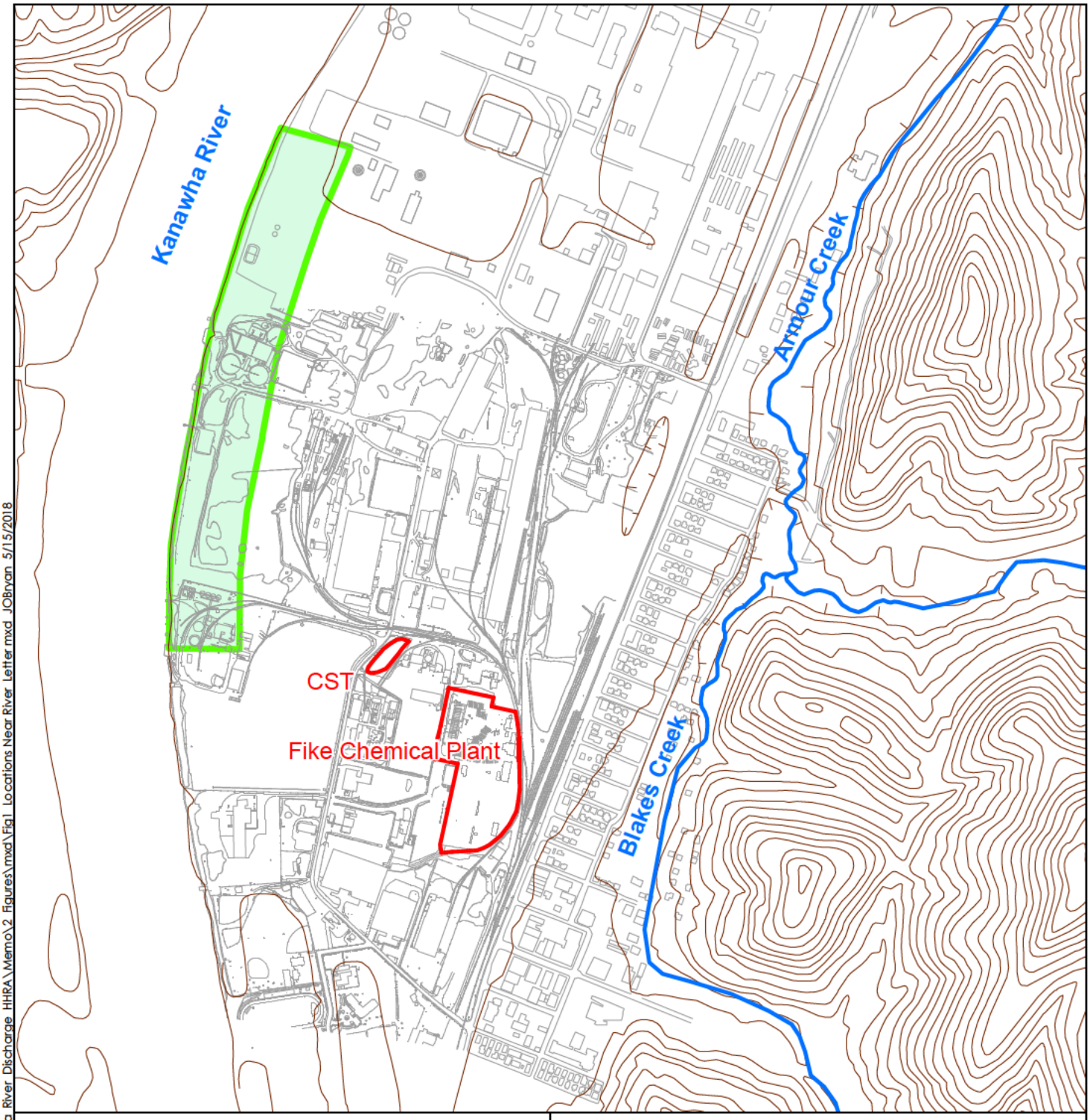
[4] A toxicological review of bis (2-chloroethyl) ether (BCEE) by the Trust recommended an adjustment to BCEE's cancer slope factor (Geosyntec, 2009b), which is currently under consideration by USEPA's Integrated Risk Information System Program (submitted on September 12, 2012). If accepted by USEPA, the revised cancer slope factor is expected to result in many of the existing concentrations of BCEE in groundwater being below the revised PRG.

[5] Gray shading indicates the minimum screening level among the three for each COC.

Definitions:

µg/L = micrograms per liter
BHC = benzene hexachloride
COC = chemical of concern
DDT = dichlorodiphenyltrichloroethane
c = cancer based screening level
n = noncancer screening level
ND = non-detect in the near-river dataset
N/A = not applicable
PRG = Preliminary Remedial Goal
RSL = Regional Screening Level
SVOC = semi-volatile organic compound
VOC = volatile organic compound
WV = West Virginia

FIGURES



\\Aro-01\pril$\fike\Deliverables\GA170606 Kanawha River Discharge HHRA\Memo\2 Figures\mxd\Fig1 Locations Near River Letter.mxd JOBryan 5/15/2018

500 ft Buffer from Kanawha River
Fike/Artel Site Boundaries
Streams
Site Features
Regional Topography (10' CI)

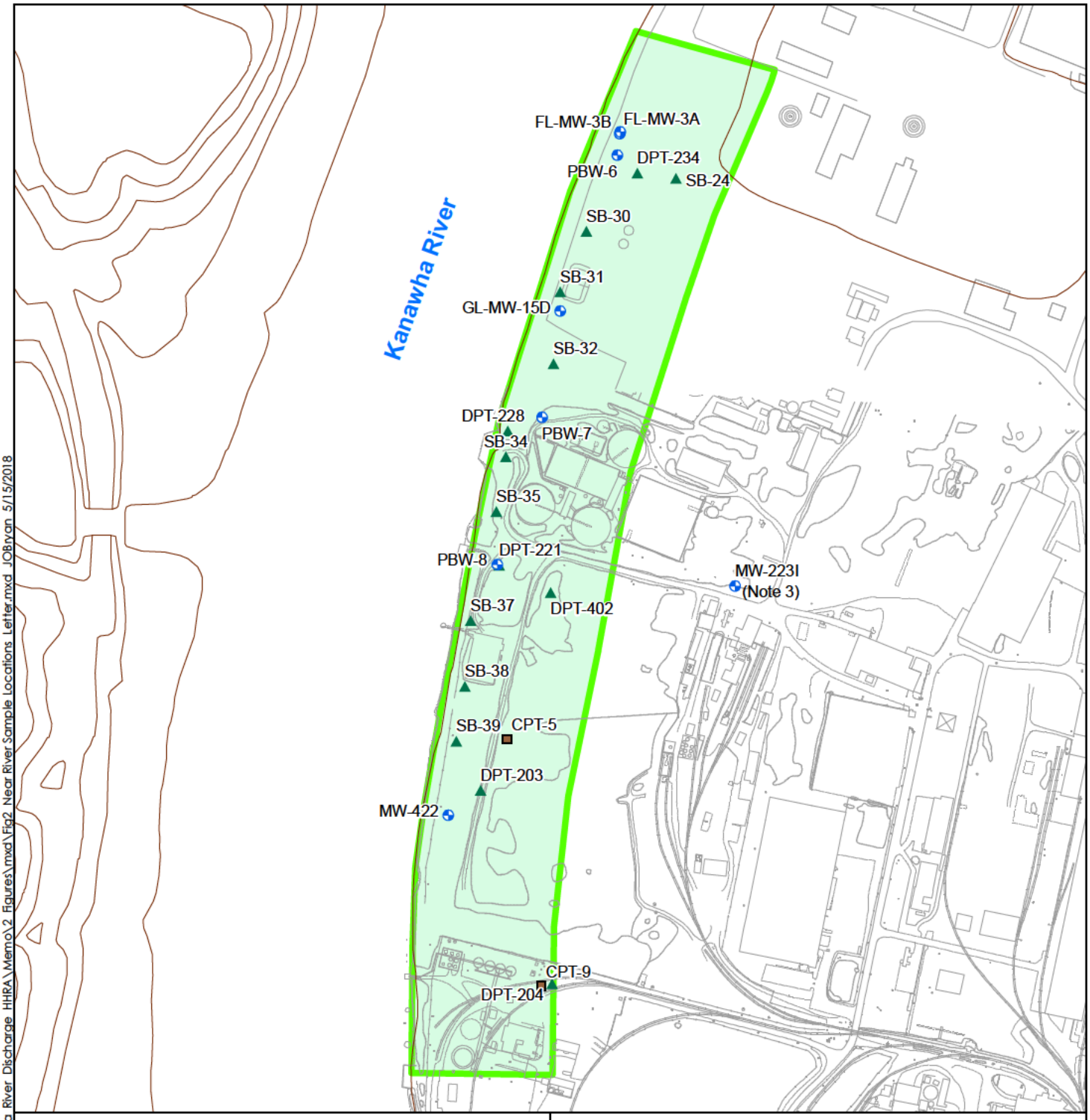
0 500 1,000 2,000 3,000 Feet

Proposed Buffer along Kanawha River

Fike/Artel Site, Nitro, WV

Note:
1. The 500 ft buffer displayed is identical to the buffer presented in *Assessment of Groundwater-Surface Interaction, Fike/Artel Superfund Site, Nitro, West Virginia* (Geosyntec, 2011).
2. ft - feet.

Geosyntec consultants	Fike/Artel Site Trust	Figure 1
Kennesaw, GA	15-May-2018	



\\Aro-01\pril$\fike\Deliverables\GA170606 Kanawha River Discharge HHRA\Memo\2 figures\mxd\Fig2 Near River Sample Locations Letter.mxd JOBryan 5/15/2018

500 ft Buffer from Kanawha River

Regional Topography (10' CI)

Site Features

Location Type

Cone Penetrometer Test

Direct Push Technology

Monitoring Well

0 250 500 1,000 1,500 Feet

Note:
1. The 500 ft buffer displayed is identical to he buffer presented in *Assessment of Groundwater-Surface Interaction, Fike/Artel Superfund Site, Nitro, West Virginia* (Geosyntec, 2011).
2. ft - feet.
3. MW-223I is included as part of the near-river dataset to provide analytical data for 4,4'-dichlorodiphenyltrichloroethane (4,4'-DDT) and aldrin. MW-223I is approximately 930-feet from the Kanawha River.

Near River Sample Locations along Kanawha River

Fike/Artel Site, Nitro, WV

Geosyntec consultants	Fike/Artel Site Trust	Figure 2
Kennesaw, GA	15-May-2018	

ATTACHMENT A

EXCERPTS FROM THE 2016 CSM UPDATE

ATTACHMENT A-1

HYDRAULIC CONDUCTIVITY DATA

N

MW-426
0.56

MW-425
3.43

MW-423
2.52

MW-424
1.52

MW-414
4.66

PBW-7
9.41

PBW-2
11.3

PR-MW-50
74.3

ROUTE 25

PRR-MW-50
55.7

PBW-8
18.4

MW-412
1.91

Pickens Road

MW-277D
5.75

R25-MW-50
42.7

MW-227I
270

IP-24
14.1

MW-422
0.58

MW-401
0.35

MW-276D
2.08

MW-219D
28.9

IP-12
9.83

MW-209I
64.1

MW-115D
44.8

MW-120D
12.9

IP-1
42.8

MW-112D
114

MW-119D
109

PW-1D
2

MW-108I
303

PW-1S
142 - 284

MW-200D
3.27

ROUTE 25

Slug Testing Locations
K - Hydraulic Conductivity
- < 10 ft/day
- 10 - 30 ft/day
- 30 - 100 ft/day
- 100 - 300 ft/day
- > 300 ft/day
- Fike/Artel Site Boundaries
- Streams
- Regional Topography (10' CI)

RI/FS Pumping Wells
- < 10 ft/day
- 100 - 300 ft/day

0 250 500 1,000 1,500
Feet

Hydraulic Conductivity Data

Fike/Artel Site, Nitro, WV

Notes:
1. Hydraulic conductivity data presented in ft/day.
2. Data for PW-1S/D in the Fike Chemical Plant represent pumping test results from the RI/FS.

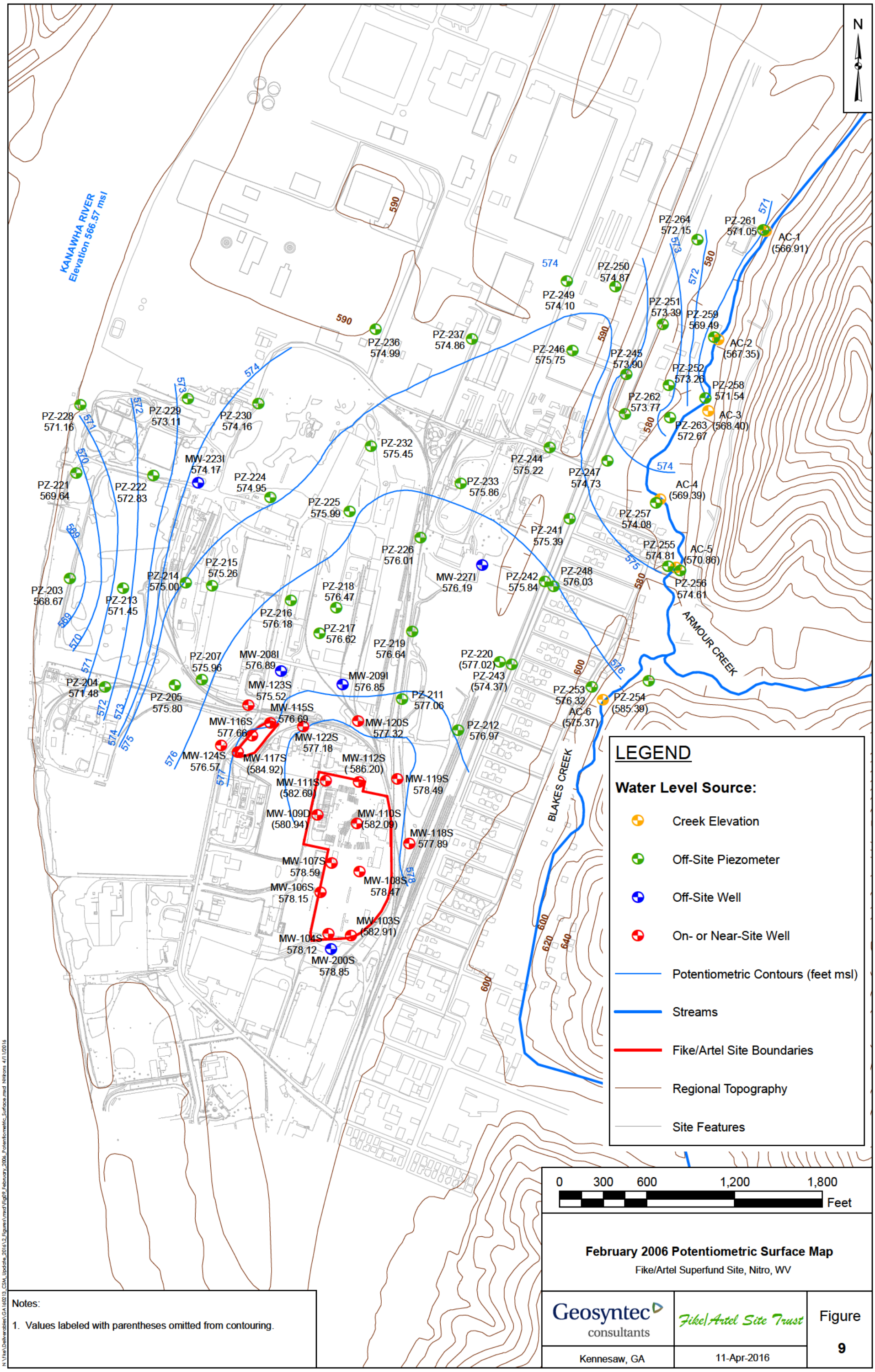
Geosyntec consultants | Fike/Artel Site Trust | Figure 8

Kennesaw, GA | 11-Apr-2016

N:\fike\Deliverables\GA160213_CSM_Update_2016\2_Figures\mxd\Fig08_Slug_Test_Data.mxd NHirons 4/11/2016

ATTACHMENT A-2

HISTORIC POTENTIOMETRIC MAPS



February 2006 Potentiometric Surface Map

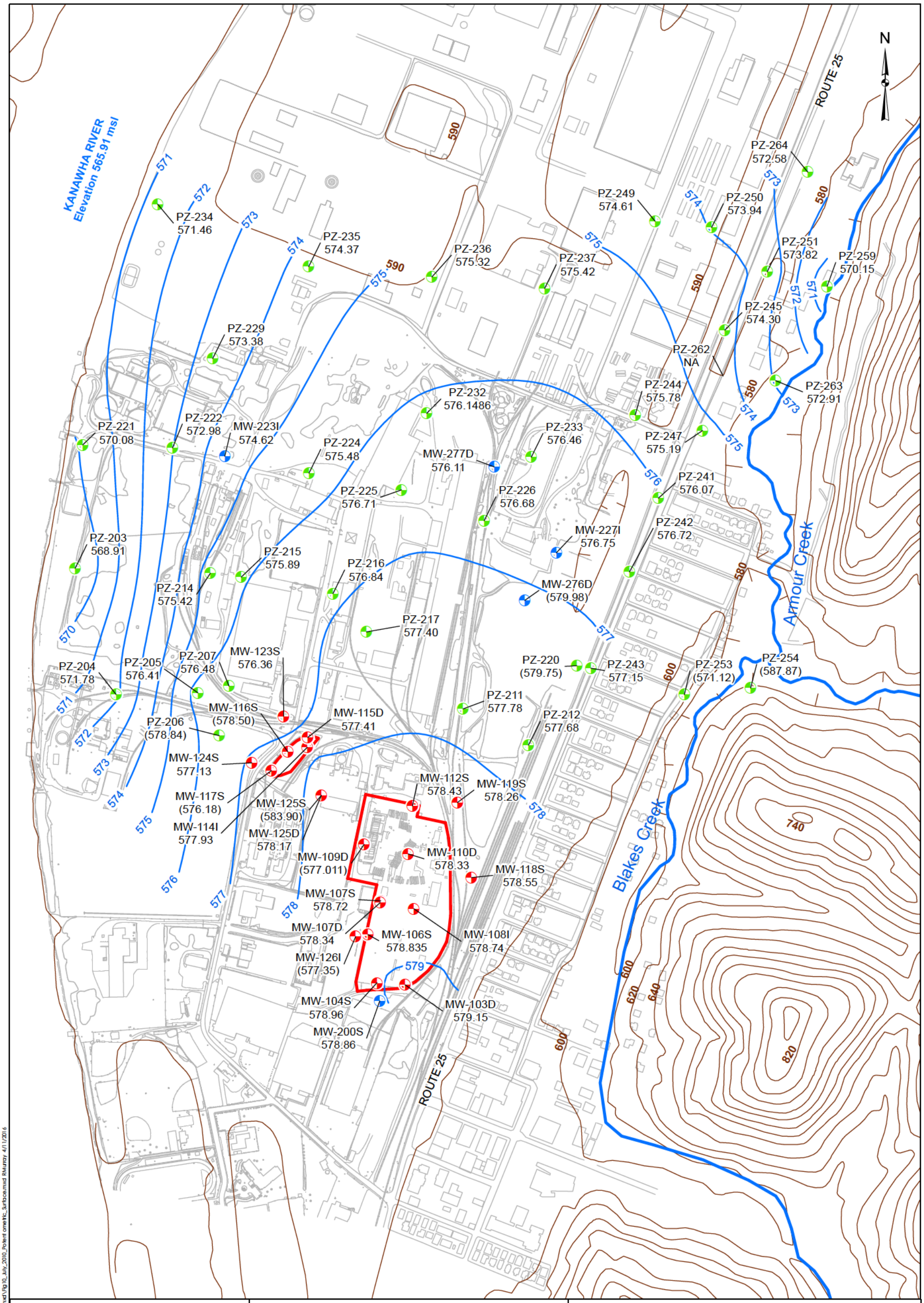
Fike/Artel Superfund Site, Nitro, WV

Notes:

1. Values labeled with parentheses omitted from contouring.

Geosyntec consultants	Fike/Artel Site Trust	Figure 9
Kennesaw, GA	11-Apr-2016	

N:\Fike\Deliverables\GA160213_CSM_Update_2016\2_Figures\mxd\Fig09_February_2006_Potentiometric_Surface.mxd NHirons 4/11/2016



Water Level Source
- Off-Site Piezometer
- Off-Site Well
- On- or Near-Site Well
- 576 Potentiometric Contours
- Streams
- Fike/Artel Site Boundaries
- Regional Topography
- Site Features

Note:
1. Water elevations are in feet above mean sea level (msl).
2. Values labeled with parentheses omitted from contouring.
3. Source for Kanawha River elevation: http://waterdata.usgs.gov/wv/nwis/rt

550 275 0 550 Feet

July 2010 Potentiometric Surface Map

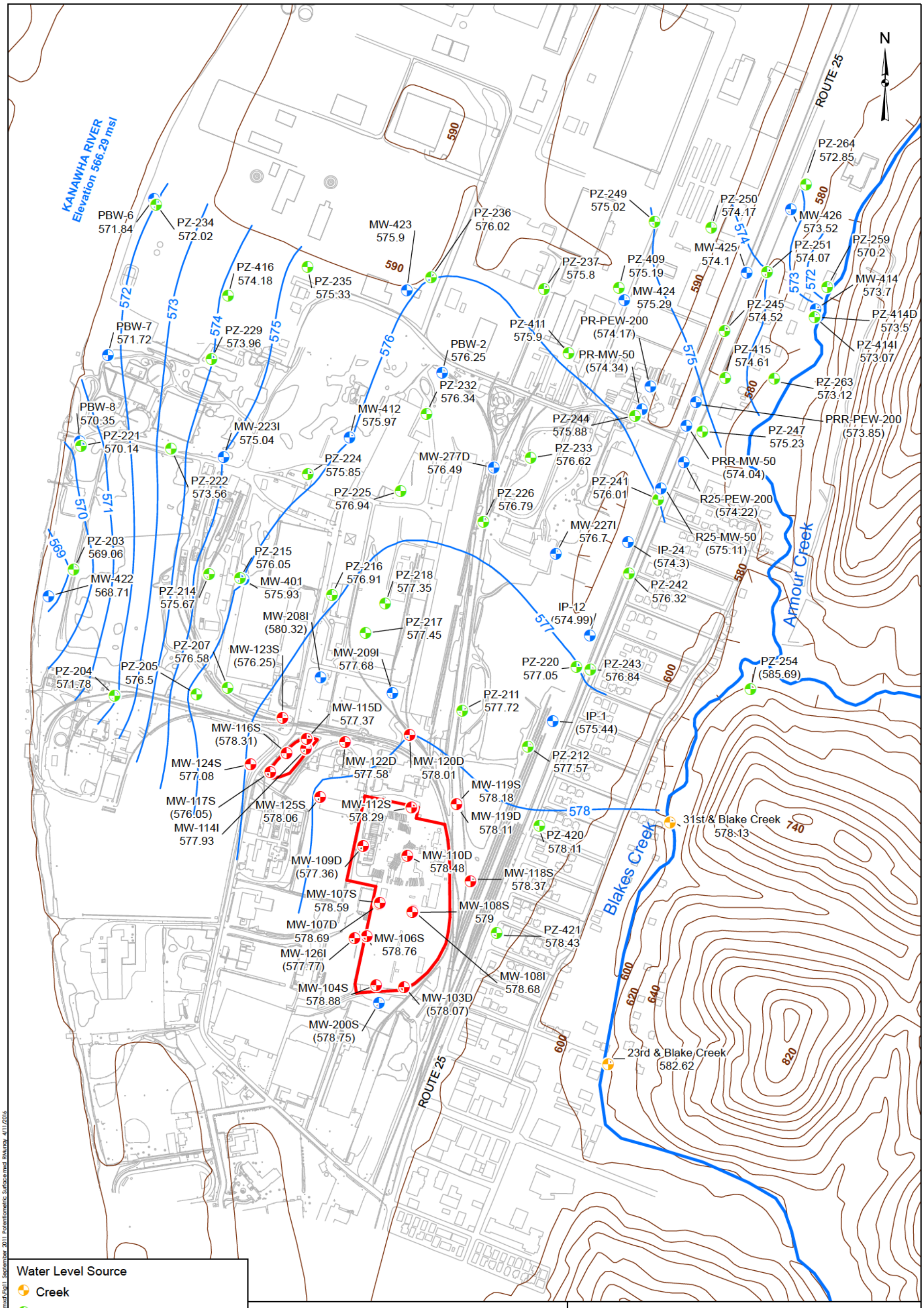
Fike/Artel Superfund Site, Nitro, WV

Geosyntec consultants — Kennesaw, GA

Fike/Artel Site Trust — 11-Apr-2016

Figure 10

N:\fike\Deliverables\GA160213.CSM_Update_2016\2_Figures\mxd\Fig10_July_2010_Potentiometric_Surface.mxd RMurray 4/11/2016



Water Level Source
- Creek
- Off-Site Piezometer
- Off-Site Well
- On- or Near-Site Well
- Potentiometric Contours (ft msl)
- Streams
- Fike/Artel Site Boundaries
- Regional Topography
- Site Features

Note:
1. Water elevations are in feet above mean sea level (msl).
2. Values labeled with parentheses omitted from contouring.
3. Source for Kanawha River elevation: http://waterdata.usgs.gov/wv/nwis/rt

550 275 0 550 Feet

September 2011 Potentiometric Surface Map
Fike/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure 11

Kennesaw, GA | 11-Apr-2016

N:\Fike\Deliverables\GA160213 CSM Update 2016\2 Figures\mxd\Fig11 September 2011 Potentiometric Surface med RMurray 4/11/2016

KANAWHA RIVER
Elevation 566.59 ft NGVD29

ROUTE 25

Armour Creek

Blakes Creek

N

PZ-234 571.50
GW-2A 573.11
MW-423 574.69
PZ-235 574.03
PZ-416 572.98
PZ-229 573.02
PBW-7 571.18
PZ-407 574.97
PZ-411 575.15
PZ-249 573.99
PZ-409 574.55
PZ-237 574.76
PZ-264 572.30
MW-426 572.97
MW-425 573.62
PZ-251 573.57
PZ-259 570.01
AC-7 (566.82)
AC-8 (567.04)
MW-414 (573.28)
AC-9 (567.85)
PZ-414I 572.59
PZ-414D (573.10)
PZ-245 573.97
PRR-PEW-200 (573.28)
PZ-415 573.97
PZ-263 572.85
PR-PEW-200 (573.59)
PZ-232 575.55
MW-412 575.19
MW-223I 574.14
PZ-244 575.28
PZ-247 574.73
PZ-233 575.89
PZ-221 570.02
PZ-224 574.97
MW-277D 575.77
PZ-222 572.84
PZ-225 576.18
PZ-226 576.22
PZ-241 575.53
R25-PEW-200 (573.73)
AC-4 (569.54)
MW-227I 576.24
PZ-203 568.95
MW-422 568.89
PZ-214 575.09
MW-401 575.34
PZ-216 576.39
PZ-242 576.25
MW-208I 576.87
PZ-207 576.04
MW-123S 576.56
MW-209I 577.23
PZ-243 576.60
AC-10 (573.28)
PZ-204 571.61
PZ-211 577.28
AC-6 (575.18)
PZ-206 (578.39)
MW-124S 576.63
MW-122S 577.47
MW-120D 577.20
PZ-212 577.21
MW-119S 577.77
MW-125S 577.61
MW-114I 577.83
MW-110S (595.93)
PZ-420 577.75
MW-118S 577.94
MW-107S 579.62
PZ-421 578.07
MW-106S 578.40
MW-104S 578.57
MW-200S 578.45

590 580 573 574 571 572 576 577 578 569 570 575 600 620 640 740 820

- Creek
- Industrial Property Well or Piezometer
- Off-Site Piezometer
- Off-Site Well
- On- or Near-Site Well
- Potentiometric Contour (ft NGVD29)
- Streams
- Fike/Artel Site Boundaries
- Regional Topography

Note:
1. Water elevations are in feet (NGVD29).
2. Values labeled with parentheses omitted from contouring.
3. Contour interval = 1 ft.
4. Source for Kanawha River elevation: http://waterdata.usgs.gov/wv/nwis

550 275 0 550 Feet

December 2015 Potentiometric Surface Map
Fike/Artel Superfund Site, Nitro, WV

Geosyntec consultants
Kennesaw, GA

Fike/Artel Site Trust
14-Apr-2016

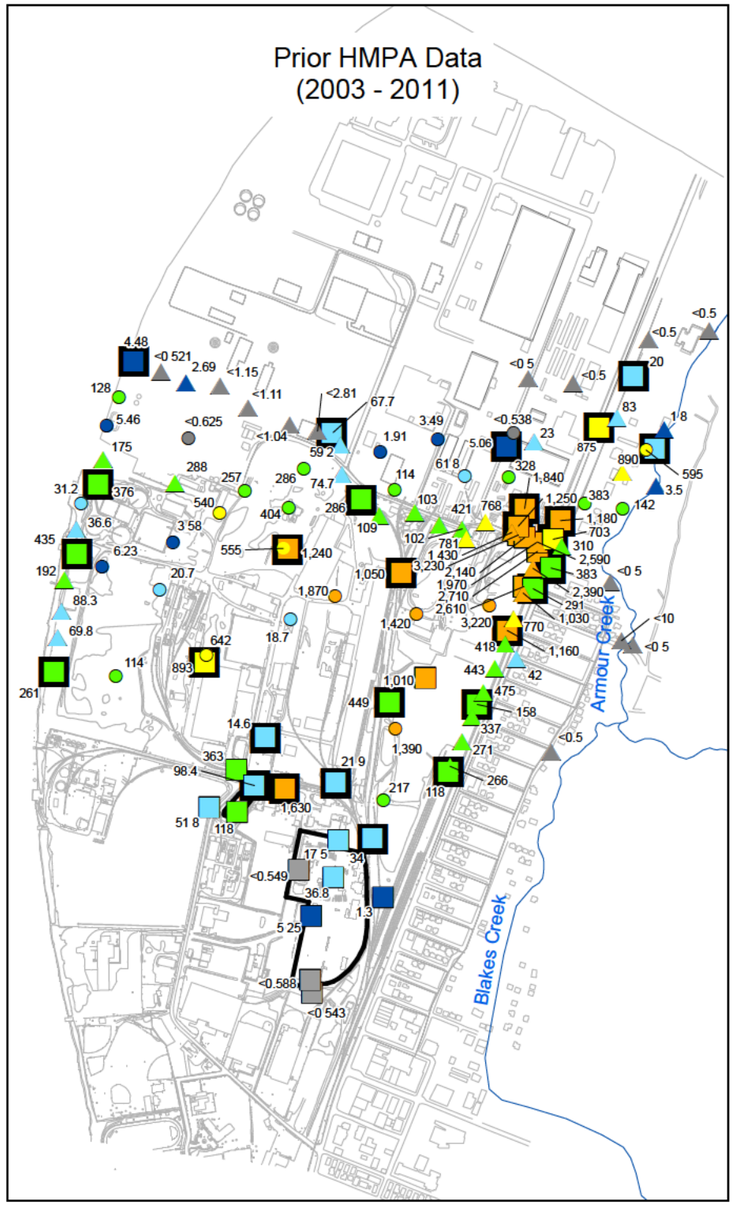
Figure
12

N:\Nitro\Deliverables\GA160213 CSM Update 2016\2 Figures\mxd\Fig12 December 2015 Potentiometric Surface.mxd RMurray 4/14/2016

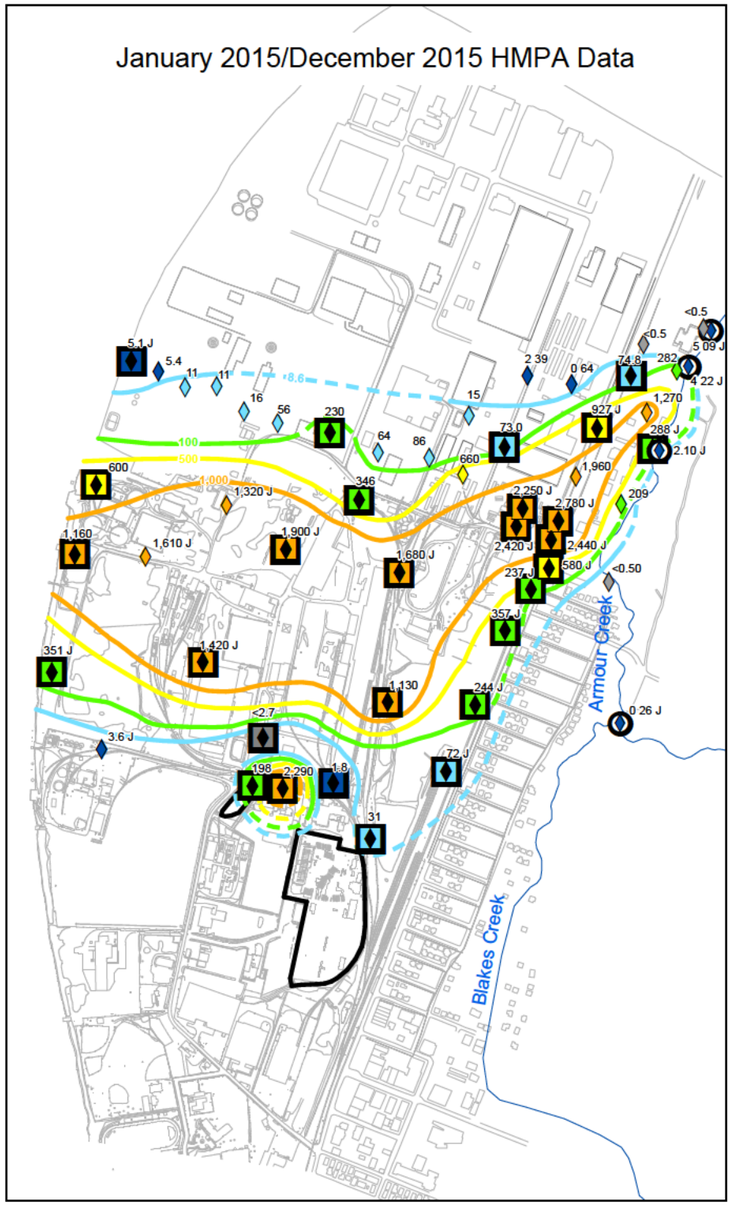
ATTACHMENT A-3

SELECT COC PLUME CONTOUR MAPS

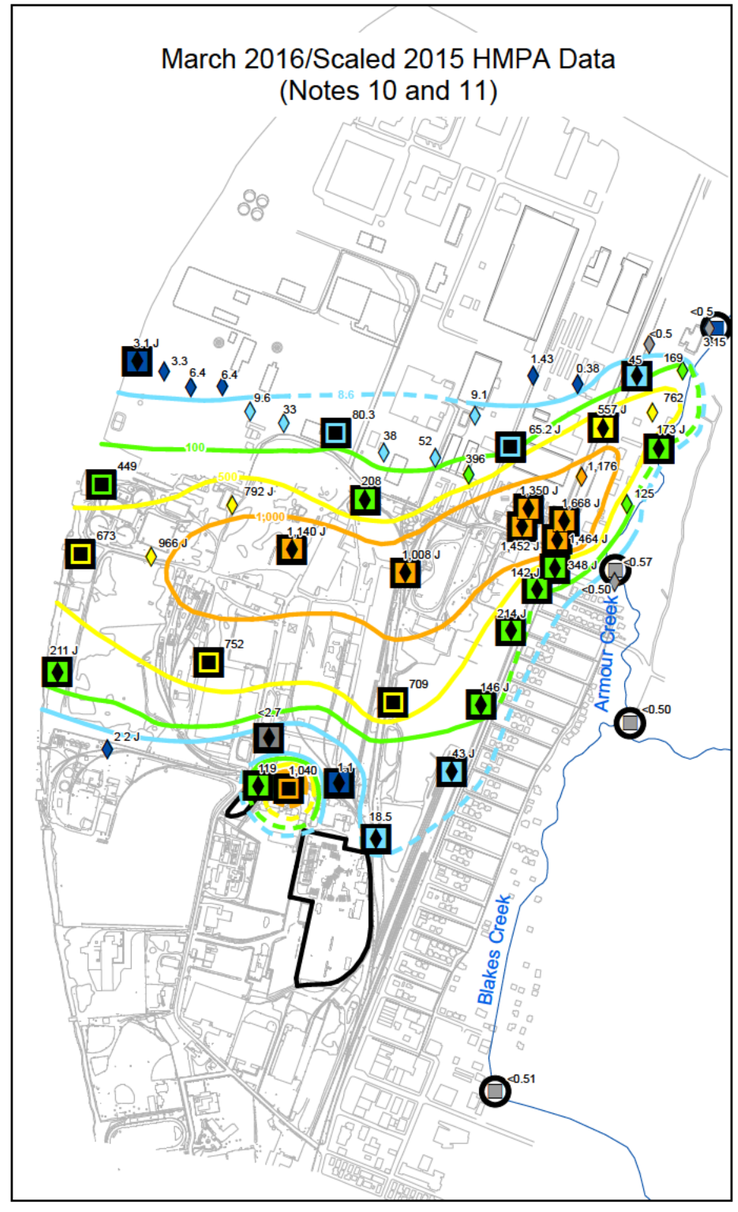
Prior HMPA Data (2003 - 2011)



January 2015/December 2015 HMPA Data



March 2016/Scaled 2015 HMPA Data (Notes 10 and 11)



N

Concentration (µg/L):
- Not Detected
- <8.6 (PRG)
- 8.6 - 100
- 100 - 500
- 500 - 1,000
- >1,000

Concentration Contour (µg/L) (dashed where inferred)
- 8.6
- 100
- 500
- 1,000

Sample Type (Note 1)
- Monitoring Well
- Long-Term Monitoring Network Well
- Surface Water Sample Location
- Fike/Artel Site Boundary
- Streams
- Site Features

Date Range
- 2003 - 2007
- 2008 - 2011
- 2015
- 2016

0 375 750 1,500 2,250 Feet

Notes:
1. Sample locations not specifically identified as monitoring wells or surface water locations are DPT locations.
2. HMPA - hexamethylphosphoramide.
3. PRG - preliminary remedial goal.
4. DPT - direct push technology.
5. µg/L - micrograms per liter.
6. Prior HMPA data represents data through 2011.
7. Qualifier: J = estimated.
8. Concentrations are color coded to match historic distribution figures in Appendix B.
9. Surface water data are color coded relative to the PRG for comparison purposes only.
10. Scaled 2015 results, which are presented for illustrative purposes only, represent 2015 HMPA concentrations that were reduced by 40% based on the average reduction observed between March 2016 and December 2015 at 7 long-term monitoring network well locations.
11. The AC-11 HMPA result from March 2016 is not shown; see Figure 2 for sample location and Table 5 for analytical result.

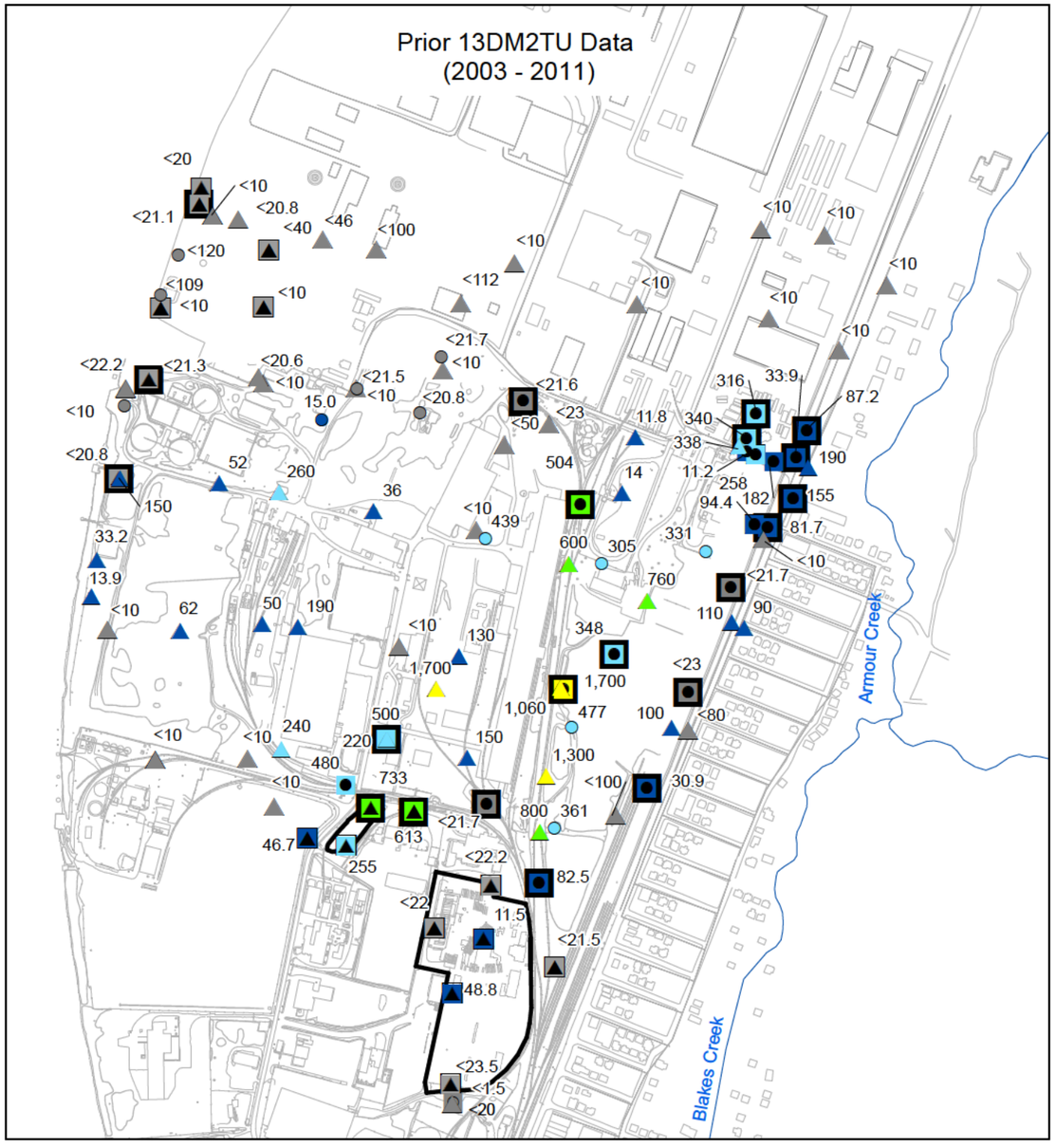
Prior and Recent HMPA Data in Deep Zone Groundwater and Surface Water

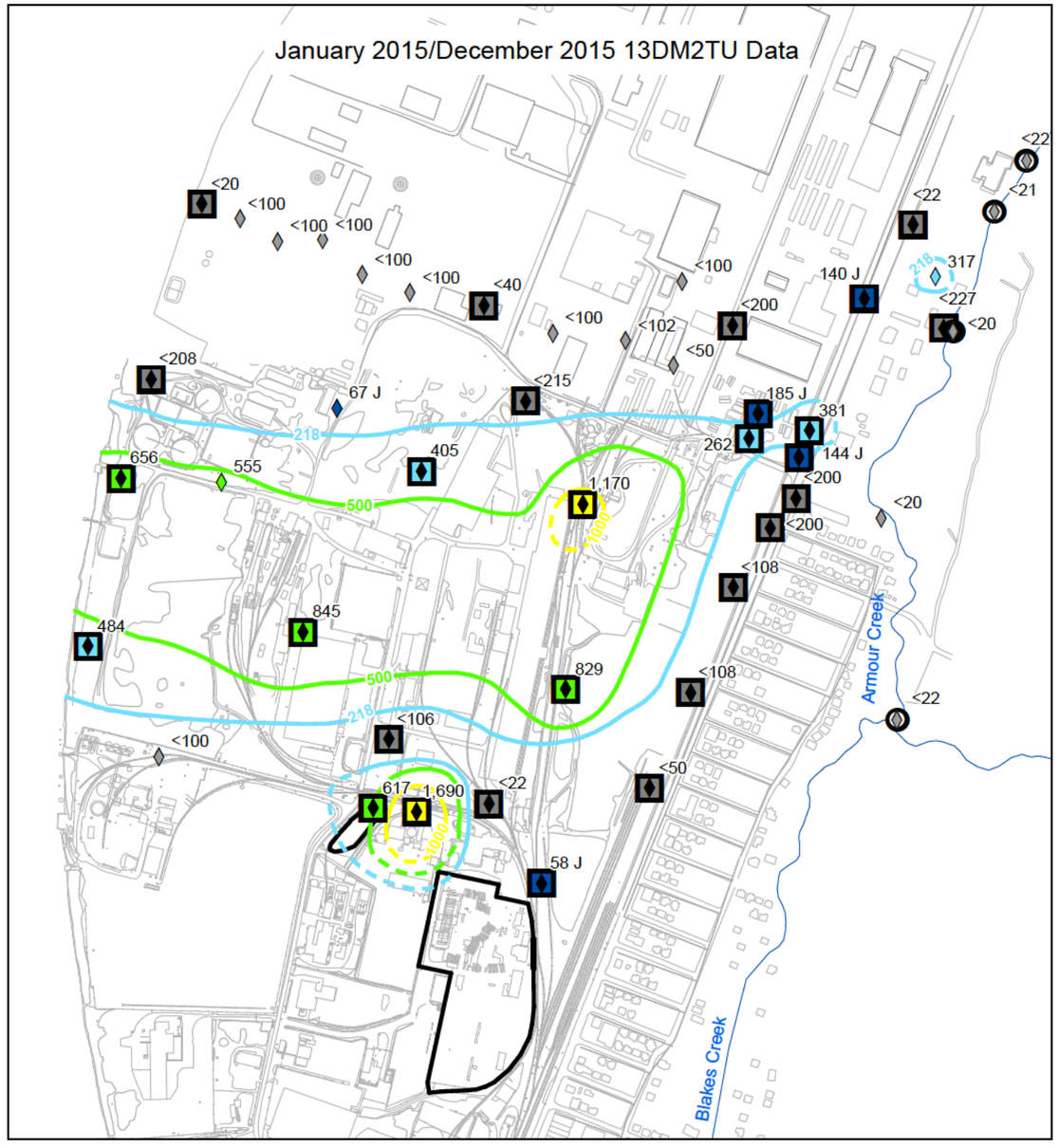
Fike/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure 13a

Kennesaw, GA | 18-May-2016

N:\fike\Deliverables\GA 160213_CSM_Update_2016\2_Figures\mxd\Playing with Symbology\Fig13a-3_PriorRecent_HMPA_Distribution_Deep_Tripanel.mxd; RMurray; 5/18/2016





N

Concentration (µg/L):
- Not Detected
- <218 (PRG)
- 218 - 500
- 500 - 1,000
- 1,000 - 2,800
- >2,800

2015 Concentration Contour (µg/L) (dashed where inferred)
- 218
- 500
- 1,000

Date Range
- 2003 - 2007
- 2008 - 2011
- 2015

Sample Type (Note 1)
- Monitoring Well
- Long-Term Monitoring Network Well
- Surface Water Sample Location
- Fike/Artel Site Boundary
- Streams
- Site Features

0 375 750 1,500 Feet

Notes:
1. Sample locations not specifically identified as monitoring wells or surface water locations are DPT locations.
2. 13DM2TU - 1,3-Dimethyl-2-Thiourea
3. PRG - preliminary remedial goal
4. DPT - direct push technology
5. µg/L - micrograms per liter
6. Prior 13DM2TU data represents data through 2011.
7. Qualifier: J = estimated
8. Concentrations are color coded to match historic distribution figures in Appendix B.
9. Surface water data are color coded relative to the PRG for comparison purposes only.

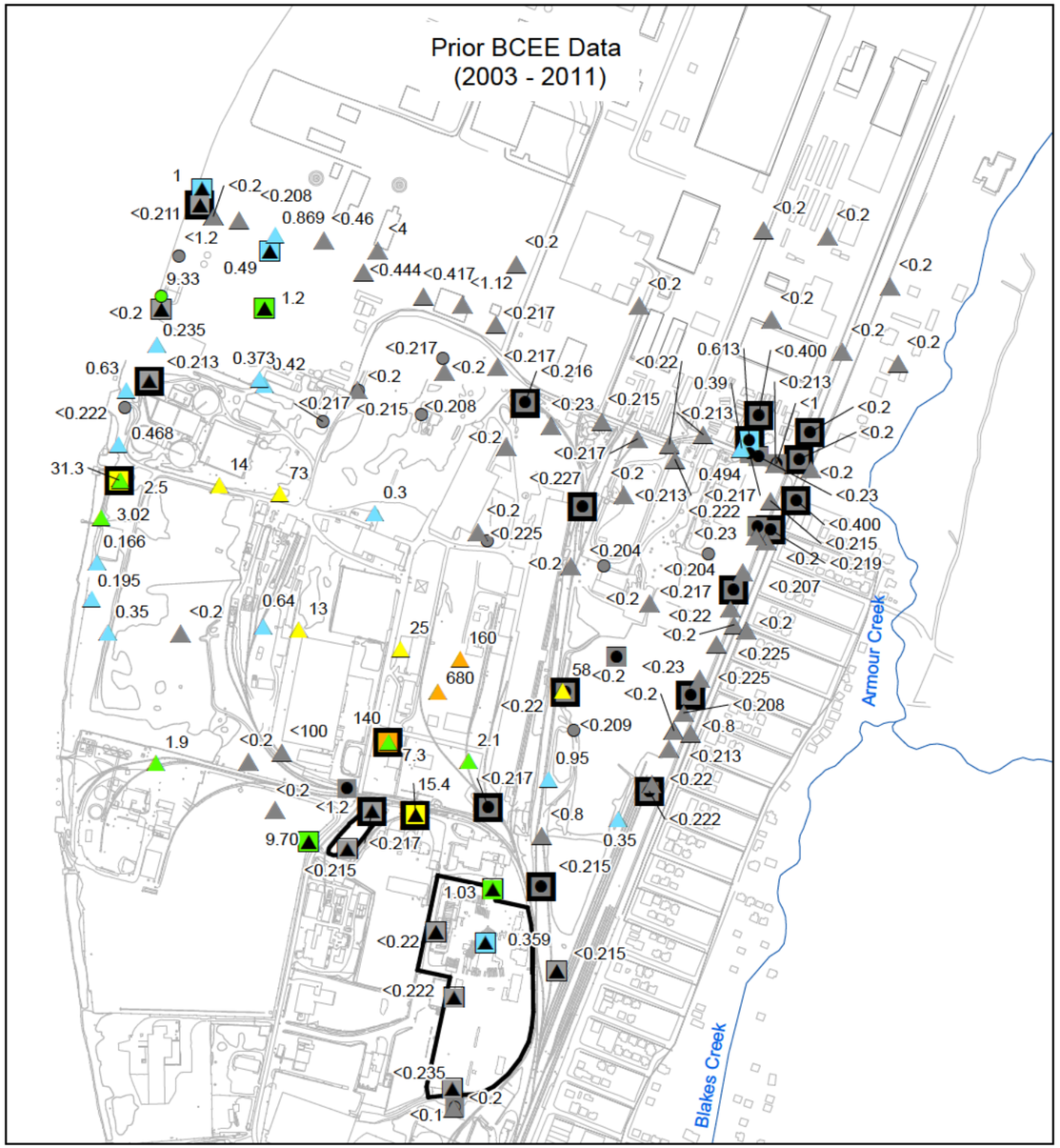
Prior and January/December 2015 13DM2TU Data in Deep Zone Groundwater and Surface Water

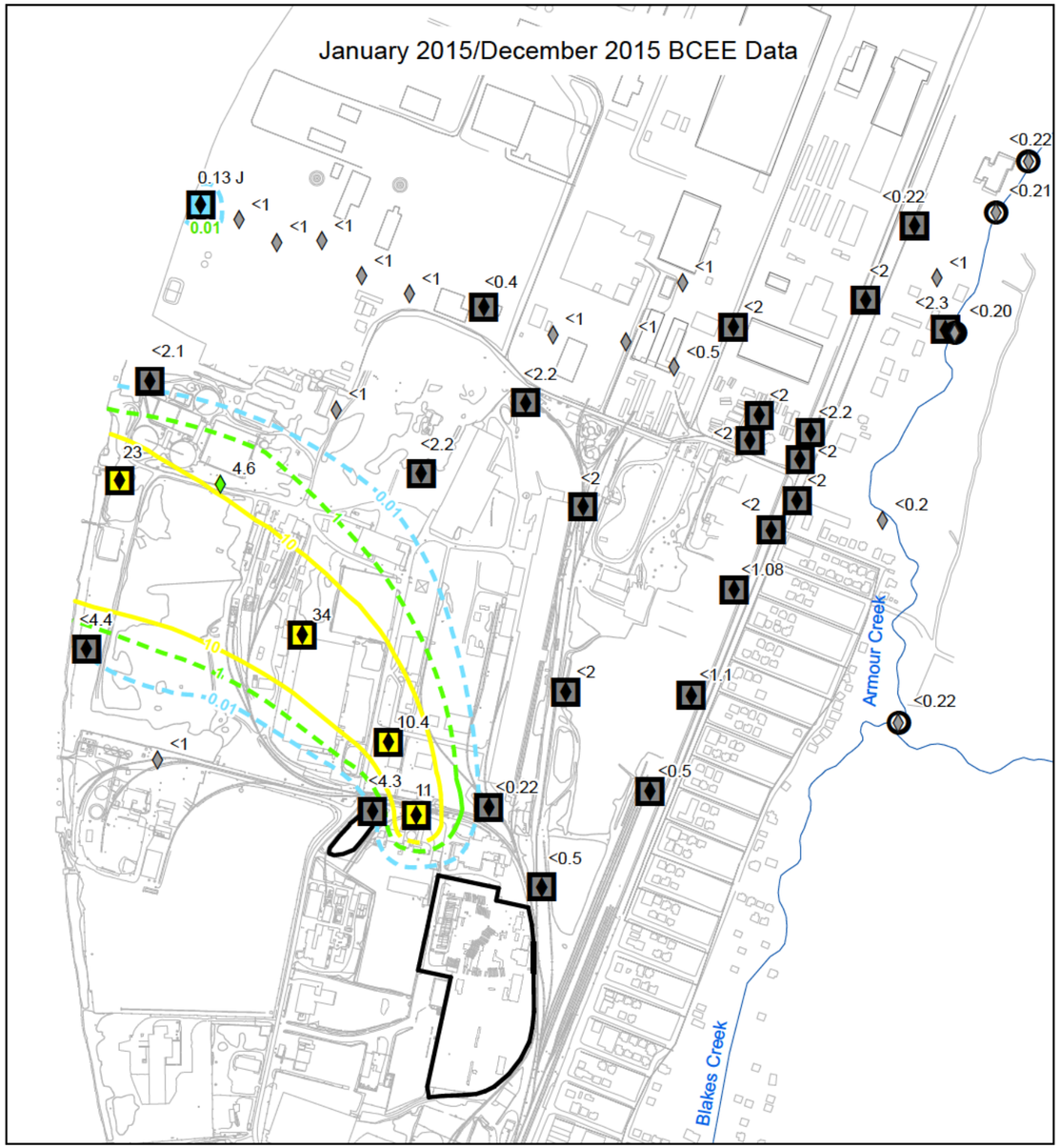
F ke/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure 14

Kennesaw, GA | 18-May-2016

N:\Fike\Deliverables\GA 160213 CSM Update 20162 Figures\mxd\Fig14 13DMT Concentration Distribution.mxd; RMurray, 5/18/2016





N

Concentration (µg/L):
- Not Detected
- <0.01 (PRG)
- 0.01 - 1
- 1 - 10
- 10 - 100
- >100

2015 Concentration Contour (µg/L) (dashed where inferred)
- 0.01
- 1
- 10

Sample Type (Note 1)
- Monitoring Well
- Long-Term Monitoring Network Well
- Surface Water Sample Location

Date Range
- 2003 - 2007
- 2008 - 2011
- 2015

- Fike/Artel Site Boundary
- Streams
- Site Features

0 375 750 1,500 Feet

Notes:
1. Sample locations not specifically identified as monitoring wells or surface water locations are DPT locations.
2. BCEE - bis(2-Chloroethyl) ether
3. PRG - preliminary remedial goal
4. DPT - direct push technology
5. µg/L - micrograms per liter
6. Prior BCEE data represents data through 2011.
7. Qualifier: J = estimated
8. Concentrations are color coded to match historic distribution figures in Appendix B.
9. Surface water data are color coded relative to the PRG for comparison purposes only.

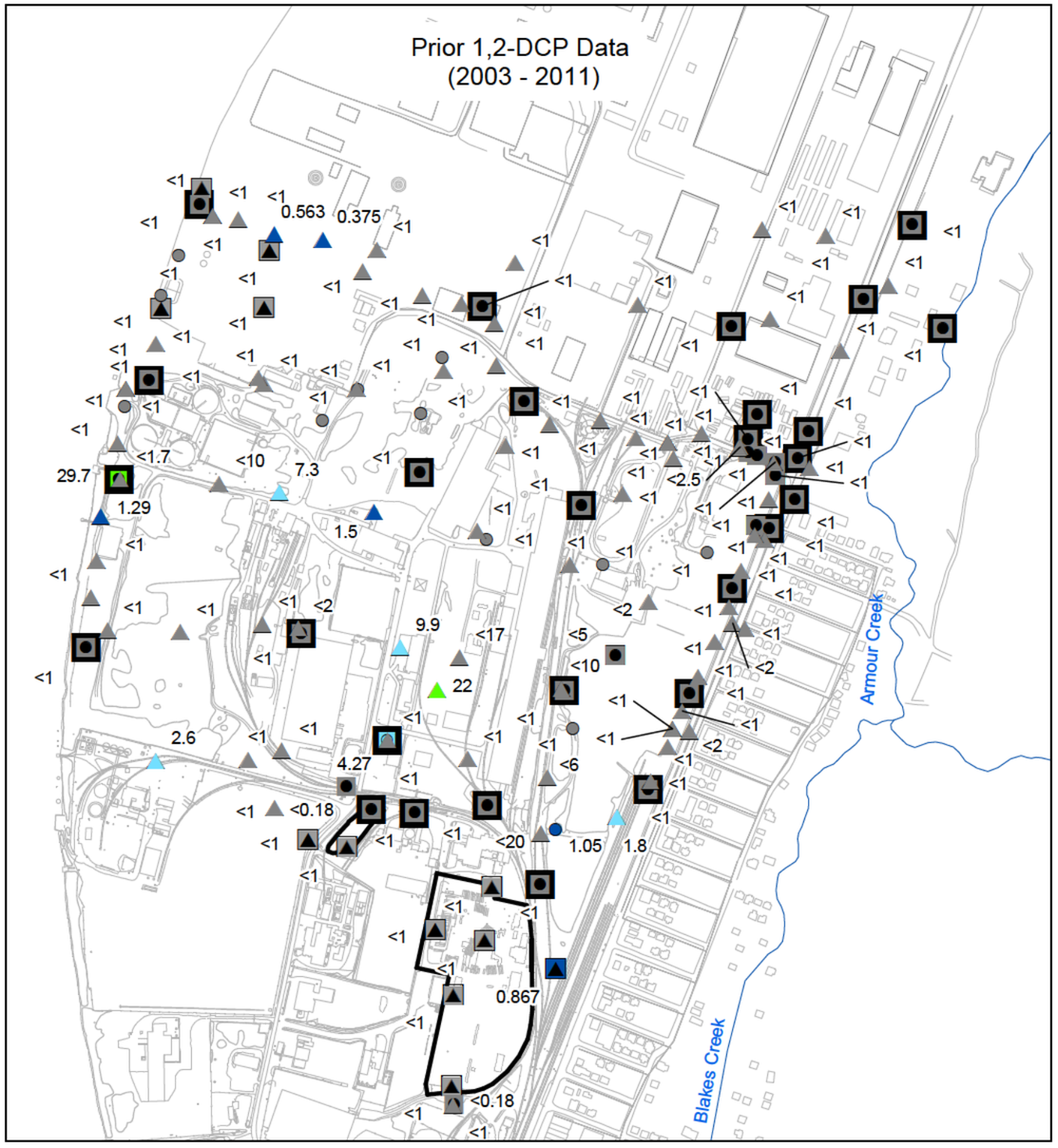
Prior and January/December 2015 BCEE Data in Deep Zone Groundwater and Surface Water

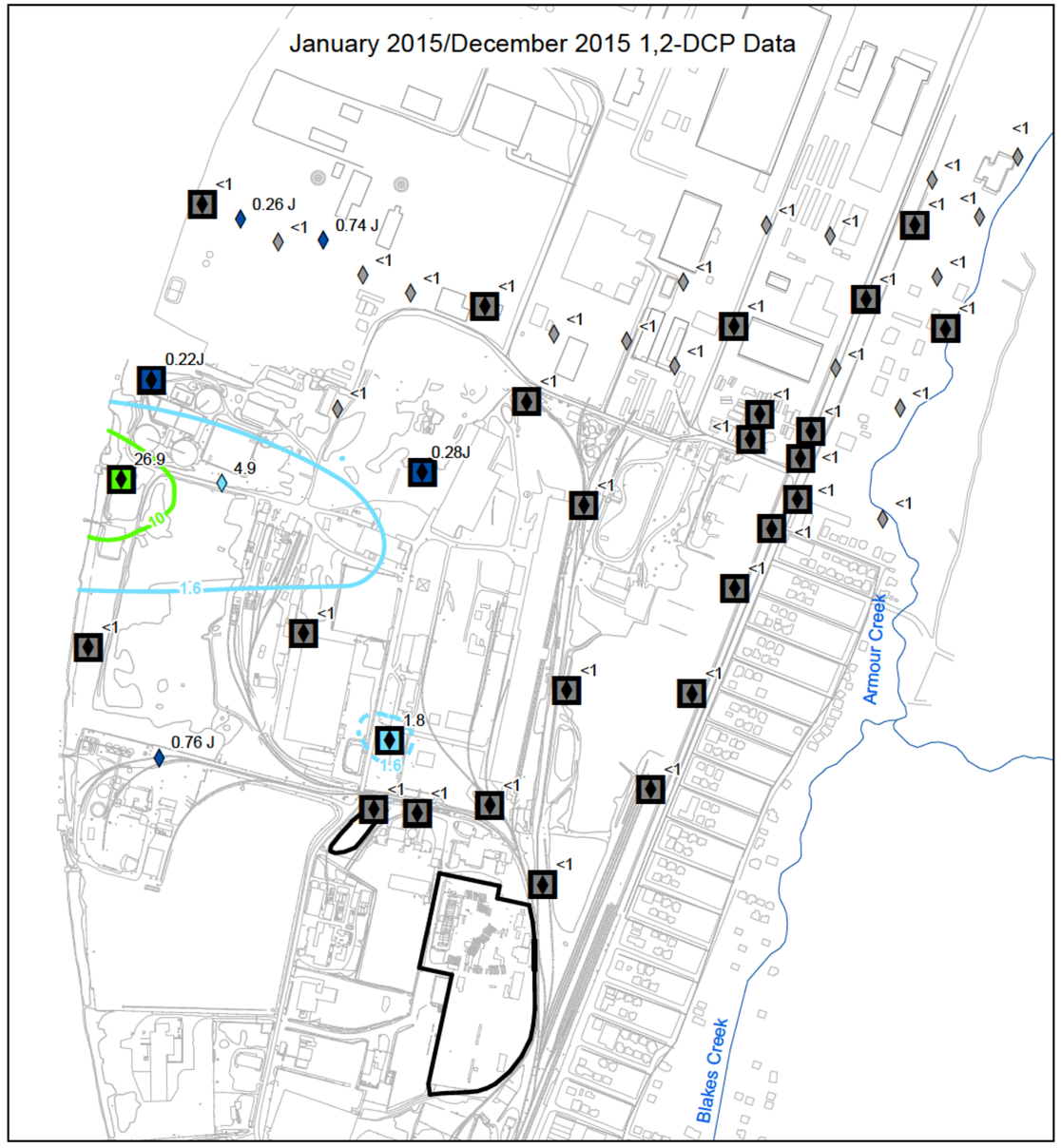
F ke/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure 15

Kennesaw, GA | 18-May-2016

N:\fike\Deliverables\GA 160213 CSM Update 20162 Figures\mxd\Fig15 BCEE Concentration Distribution.mxd; RMurray; 5/18/2016





N

Concentration (µg/L)
- Not Detected
- <1.6 (PRG)
- 1.6 - 10
- 10 - 100
- >100

2015 Concentration Contour (µg/L) (dashed where inferred)
- 1.6
- 10

Sample Type (Note 1)
- Monitoring Well
- Long-Term Monitoring Network Well

Date Range
- 2003 - 2007
- 2008 - 2011
- 2015

- Fike/Artel Site Boundary
- Streams
- Site Features

Notes:
1. Sample locations not specifically identified as monitoring wells are DPT locations.
2. 1,2-DCP - 1,2-Dichloropropane
3. PRG - preliminary remedial goal
4. DPT - direct push technology
5. µg/L - micrograms per liter
6. Prior 1,2-DCP data represents data through 2011.
7. Qualifier: J = estimated
8. Concentrations are color coded to match historic distribution figures in Appendix B.

0 375 750 1,500 Feet

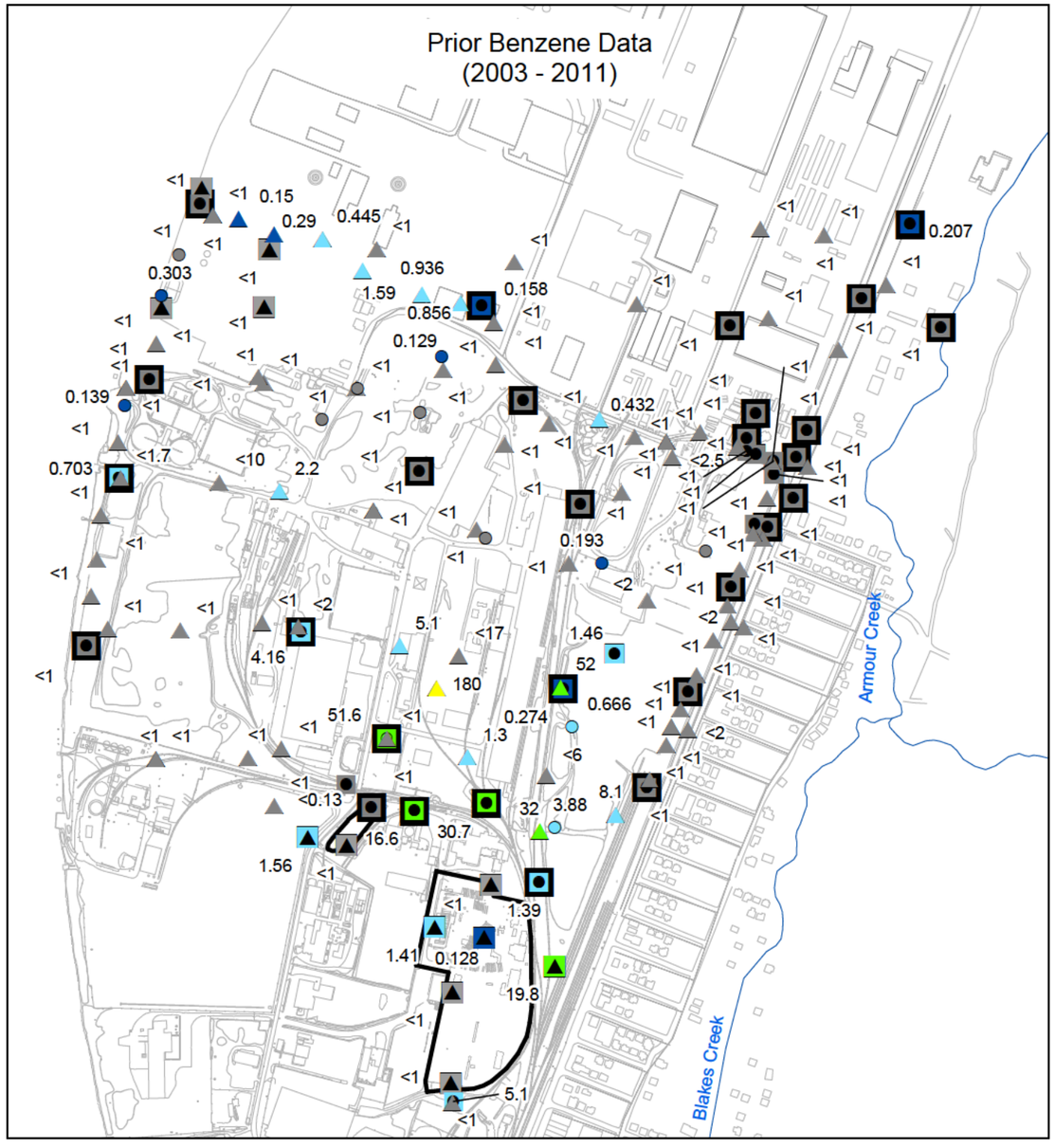
Prior and January/December 2015 1,2-DCP Data in Deep Zone Groundwater

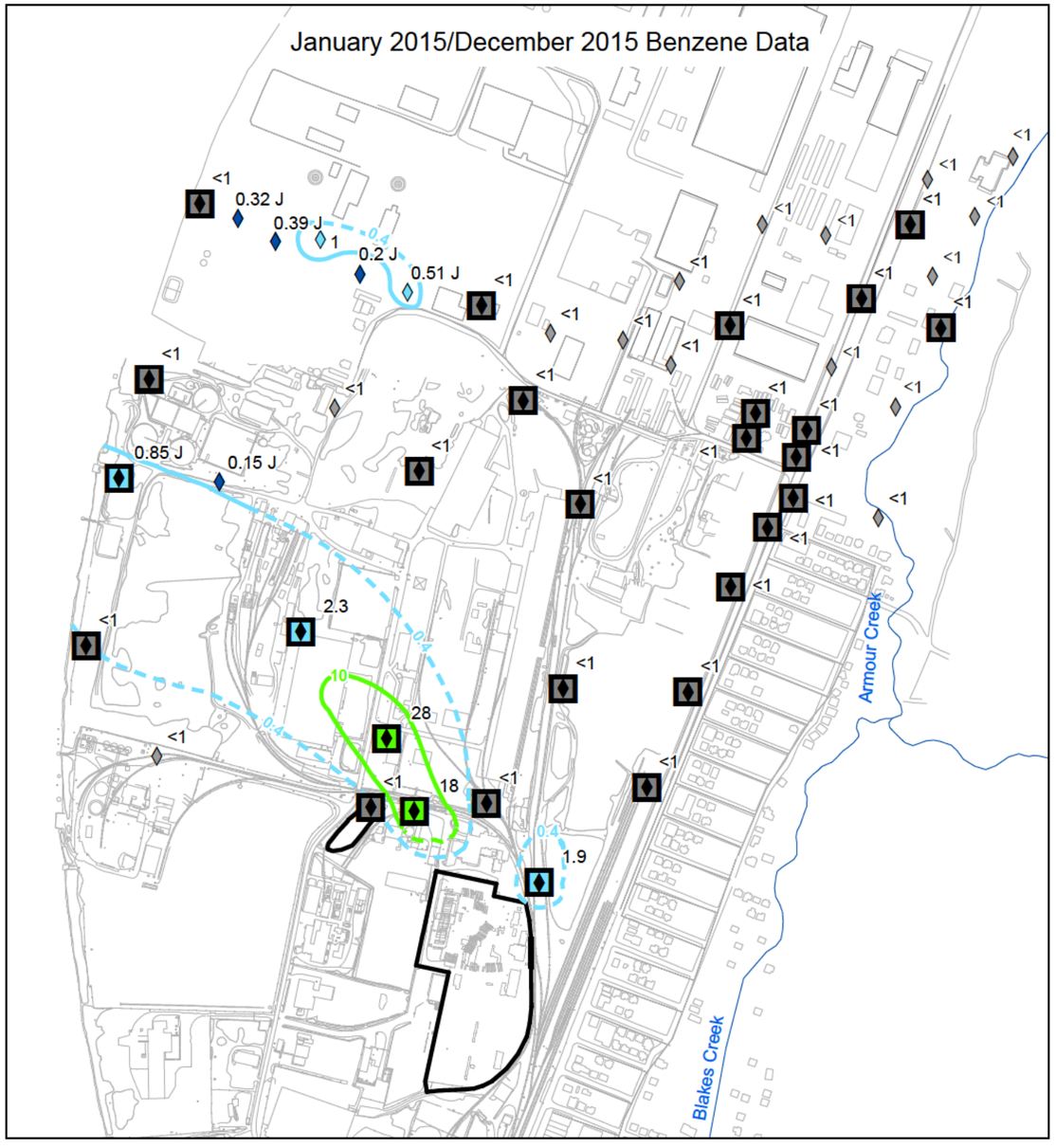
F ke/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure 16

Kennesaw, GA | 18-May-2016

N:\fike\Deliverables\GA 160213 CSM Update 20162 Figures\mxd\Fig16 12DCP Concentration Distribution.mxd, RMurray, 5/18/2016





N

Concentration (µg/L):
- Not Detected
- <0.4 (PRG)
- 0.4 - 10
- 10 - 100
- 100 - 1,000
- >1,000

2015 Concentration Contour (µg/L) (dashed where inferred)
- 0.4
- 10

Sample Type (Note 1)
- Monitoring Well
- Long-Term Monitoring Network Well

Date Range
- 2003 - 2007
- 2008 - 2011
- 2015

- Fike/Artel Site Boundary
- Streams
- Site Features

Notes:
1. Sample locations not specifically identified as monitoring wells are DPT locations.
2. PRG - preliminary remedial goal
3. DPT - direct push technology
4. µg/L - micrograms per liter
5. Prior benzene data represents data through 2011.
6. Qualifier: J = estimated
7. Concentrations are color coded to match historic distribution figures in Appendix B.

0 375 750 1,500 Feet

Prior and January/December 2015 Benzene Data in Deep Zone Groundwater

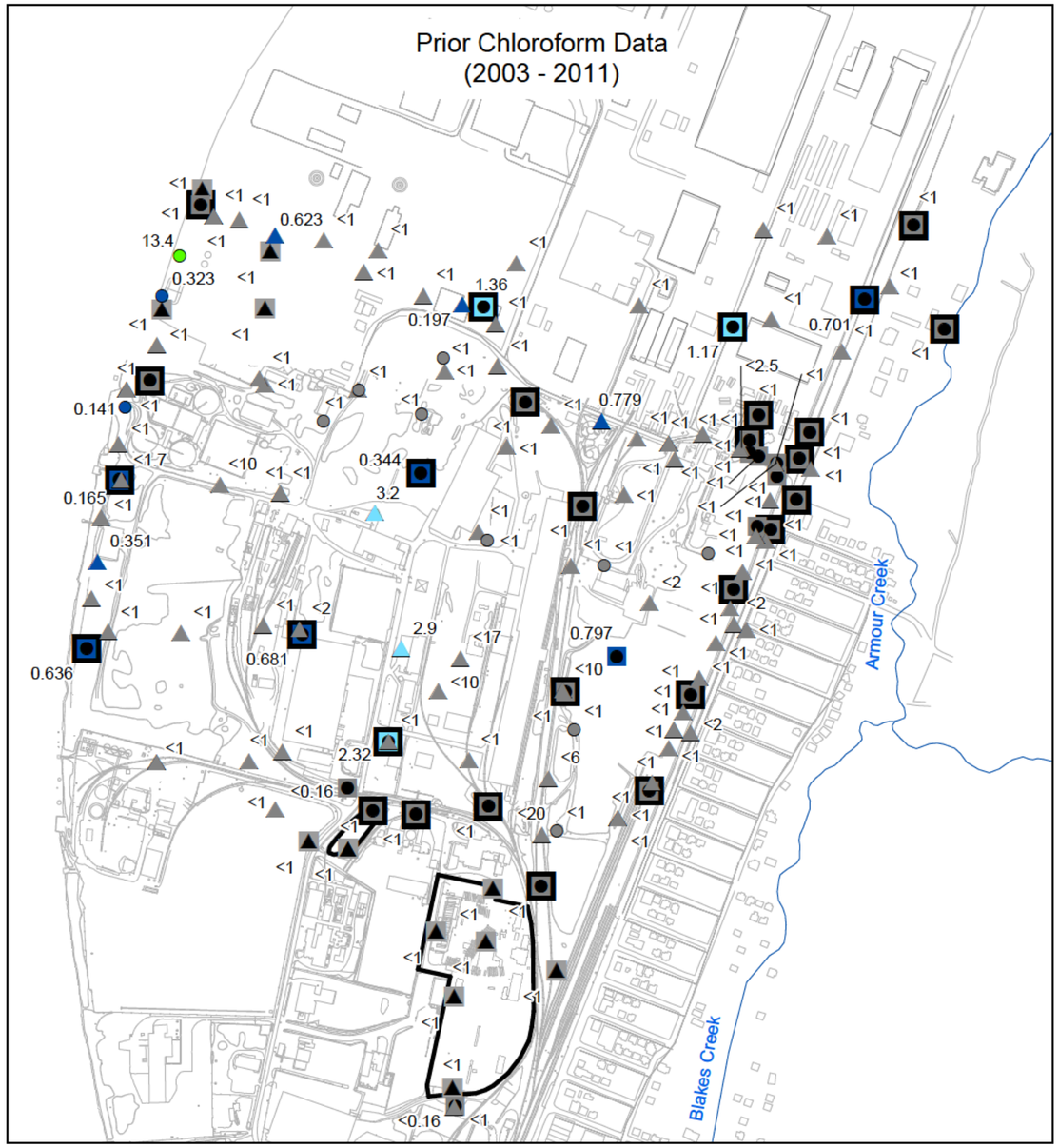
Fike/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure 17

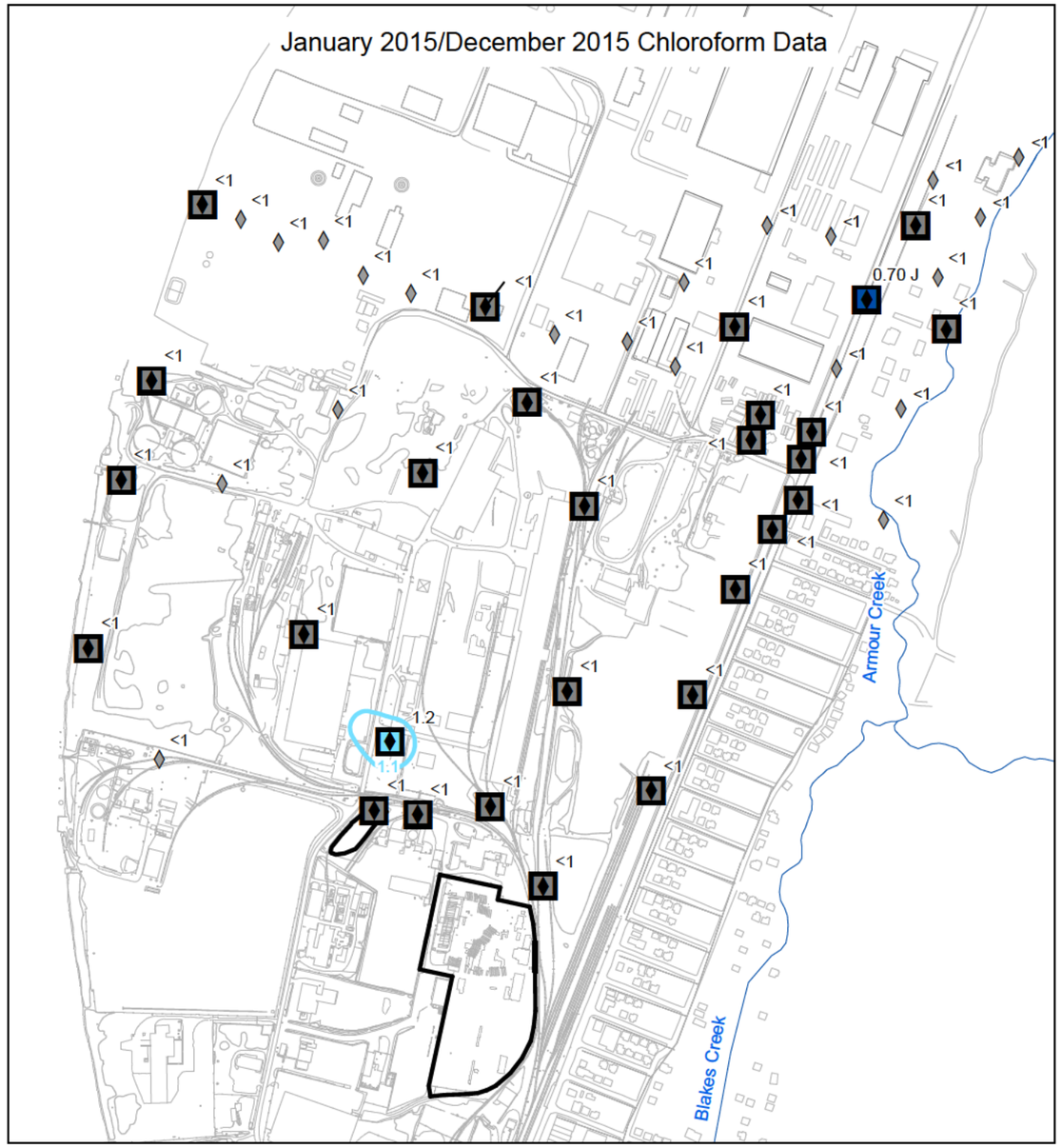
Kennesaw, GA | 18-May-2016

N:\fike\Deliverables\GA160213_CSM_Update_2016\2_Figures\mxd\Fig17_Benzene_Concentration_Distribution_Deep_.mxd; RMurray; 5/18/2016

Prior Chloroform Data (2003 - 2011)



January 2015/December 2015 Chloroform Data



N

Concentration (µg/L):
- Not Detected
- <1.1 (PRG)
- 1.1 - 10
- 10 - 100
- >100

2015 Concentration Contour (µg/L) (dashed where inferred)
- 1.1

Sample Type (Note 1)
- Monitoring Well
- Long-Term Monitoring Network Well

Date Range
- 2003 - 2007
- 2008 - 2011
- 2015

- Fike/Artel Site Boundary
- Streams
- Site Features

Notes:
1. Sample locations not specifically identified as monitoring wells are DPT locations.
2. PRG - preliminary remedial goal
3. DPT - direct push technology
4. µg/L - micrograms per liter
5. Prior chloroform data represents data through 2011.
6. Qualifier: J = estimated
7. Concentrations are color coded to match historic distribution figures in Appendix B.

0 375 750 1,500 Feet

Prior and January/December 2015 Chloroform Data in Deep Zone Groundwater

Fike/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure 18

Kennesaw, GA | 18-May-2016

N:\fike\Deliverables\GA160213_CSM_Update_2016\2_Figures\mxd\Fig18_Chloroform_Concentration_Distribution_Deep_.mxd; RMurray; 5/18/2016

Prior VC Data
(2003 - 2011)

January 2015/December 2015 VC Data

N

Armour Creek

Blakes Creek

Concentration (µg/L):
- Not Detected
- <0.07 (PRG)
- 0.07 - 1
- 1 - 10
- 10 - 100
- >100

2015 Concentration Contour (µg/L)
(dashed where inferred)
- 0.07
- 1
- 10
- 100

Sample Type (Note 1)
- Monitoring Well
- Long-Term Monitoring Network Well

Date Range
- 2003 - 2007
- 2008 - 2011
- 2015

- Fike/Artel Site Boundary
- Streams
- Site Features

Notes:
1. Sample locations not specifically identified as monitoring wells are DPT locations.
2. VC - vinyl chloride
3. PRG - preliminary remedial goal
4. DPT - direct push technology
5. µg/L - micrograms per liter
6. Prior VC data represents data through 2011.
7. Qualifier: J = estimated
8. Concentrations are color coded to match historic distribution figures in Appendix B.

0 375 750 1,500 Feet

Prior and January/December 2015 VC Data in Deep Zone Groundwater

F ke/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure 19

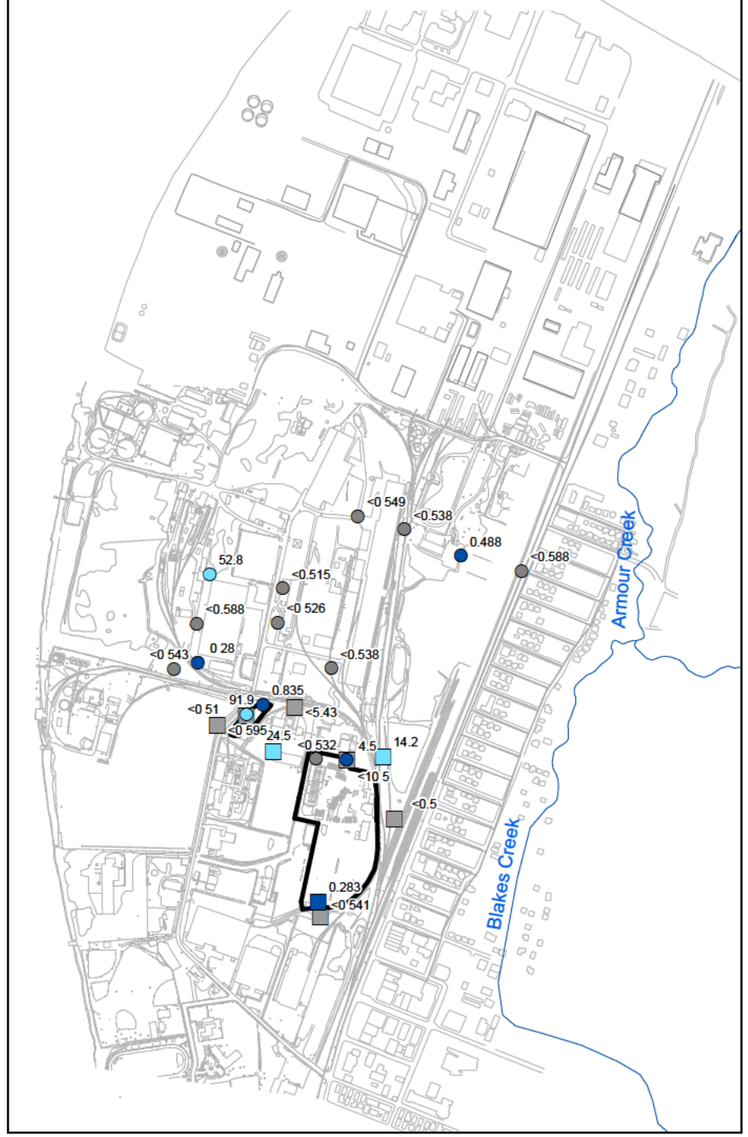
Kennesaw, GA | 18-May-2016

N:\fike\Deliverables\GA 160213 CSM Update 20162 Figures\mxd\Fig19 VC Concentration Distribution.mxd; RMurray; 5/18/2016

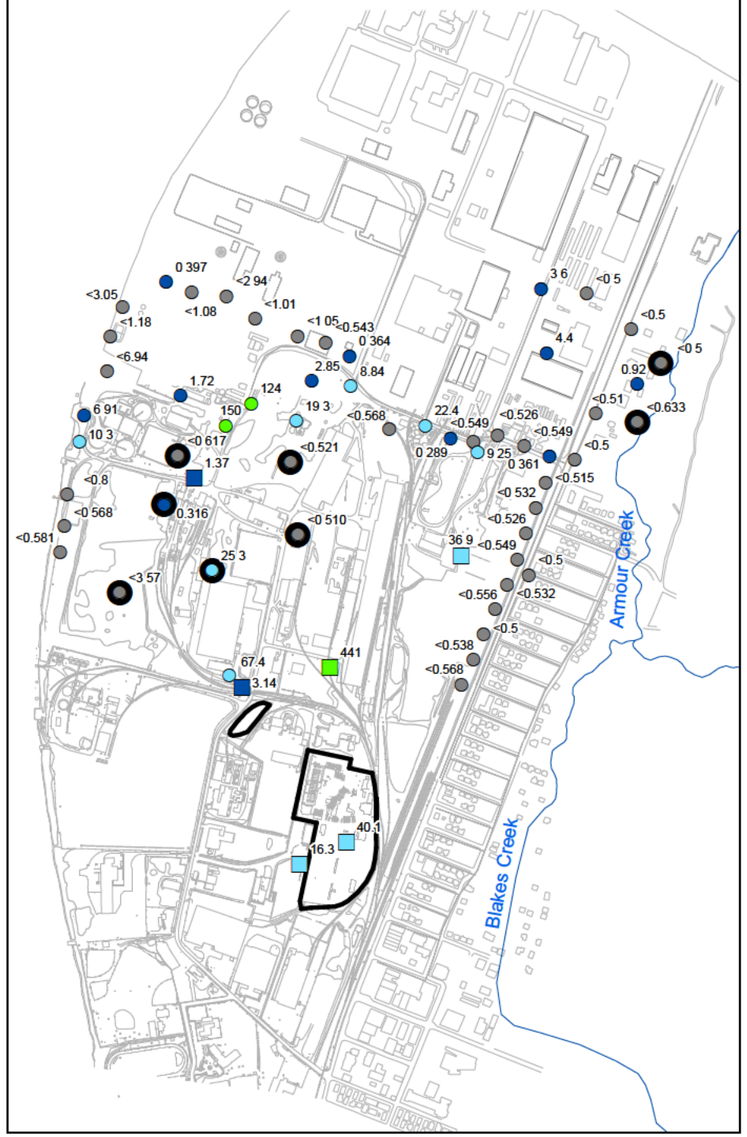
ATTACHMENT A-4

HISTORIC COC DISTRIBUTION MAPS

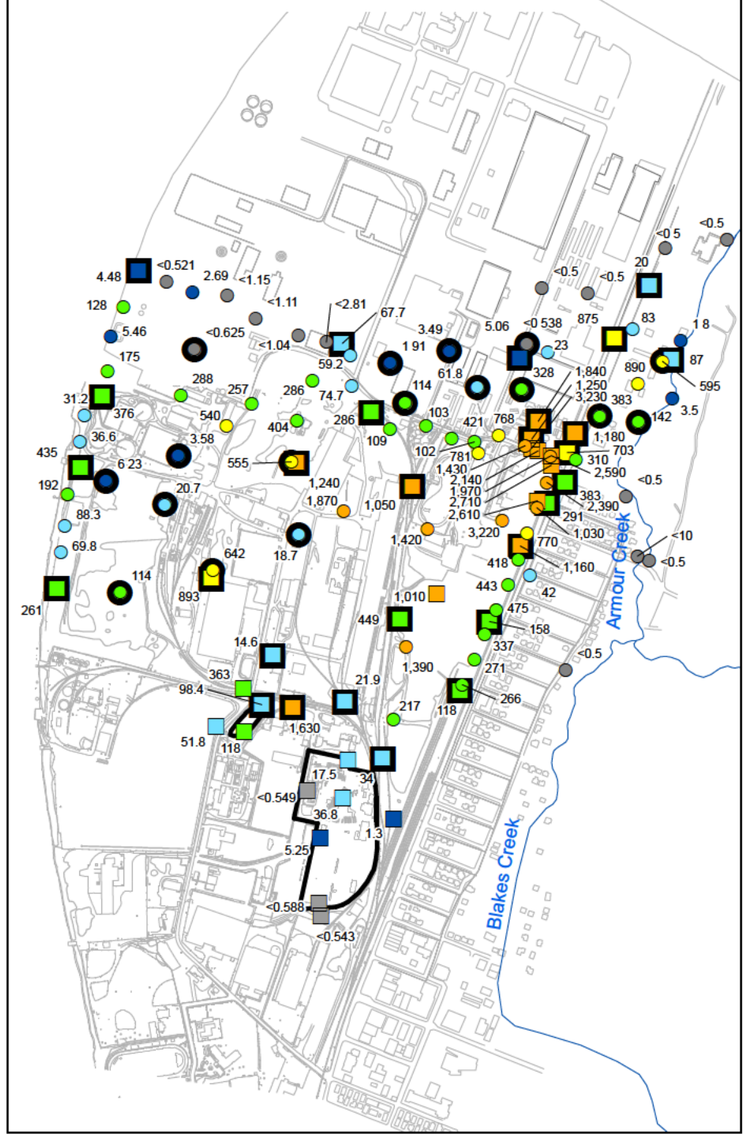
SHALLOW SAMPLING INTERVAL



INTERMEDIATE SAMPLING INTERVAL



DEEP SAMPLING INTERVAL



Concentration (ug/L):
- Not Detected
- 0 - 8.6 (PRG)
- 8.6 - 100
- 100 - 500
- 500 - 1,000
- 1,000 - 3,200

- 2010-2011 DPT Locations
- Long-Term Monitoring Network

Sample Type
- DPT
- Monitoring Well

- Fike/Artel Site Boundary
- Streams
- Site Features

Note:
Data are the most current data for each location from investigation phases and routine monitoring data. The 2004-2005 pilot test data are not included.

0 500 1,000 2,000 3,000 Feet

Hexamethylphosphoramide Concentration Distribution

Fike/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure B-1

Kennesaw, GA | 18-May-2016

N:\Fike\Deliverables\GA 160213 CSM Update 2016\3 Appendices\Appendix B Historic Distribution Maps\mxd\FigB-1 HMPA Concentration Distribution.mxd; RMurray; 5/18/2016

SHALLOW SAMPLING INTERVAL

INTERMEDIATE SAMPLING INTERVAL

DEEP SAMPLING INTERVAL

N

Armour Creek

Blakes Creek

Concentration (ug/L):
- Not Detected
- 0 - 218 (PRG)
- 218 - 500
- 500 - 1,000
- 1,000 - 2,800
- 2,800 - 3,500

Sample Type
- DPT
- Monitoring Well

- Fike/Artel Site Boundary
- Streams
- Site Features

Note:
Data are the most current data for each location from investigation phases and routine monitoring data. The 2004-2005 pilot test data are not included.

0 500 1,000 2,000 3,000 Feet

1,3-Dimethyl-2-Thiourea Concentration Distribution

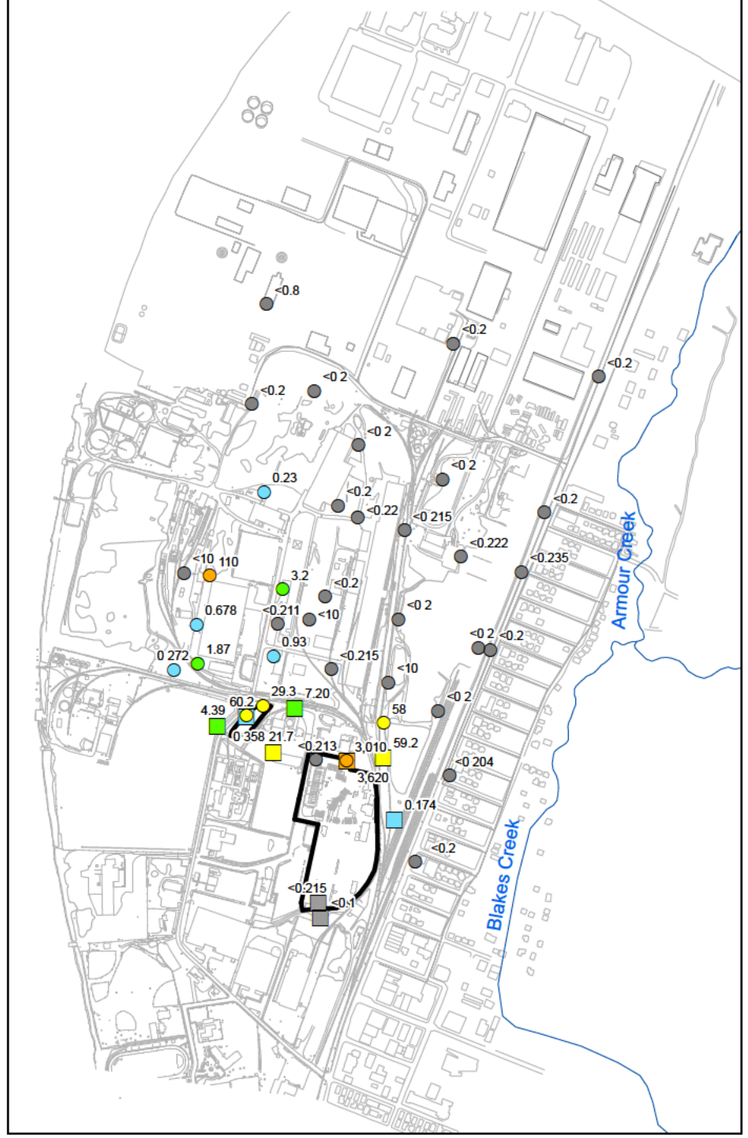
Fike/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure B-2

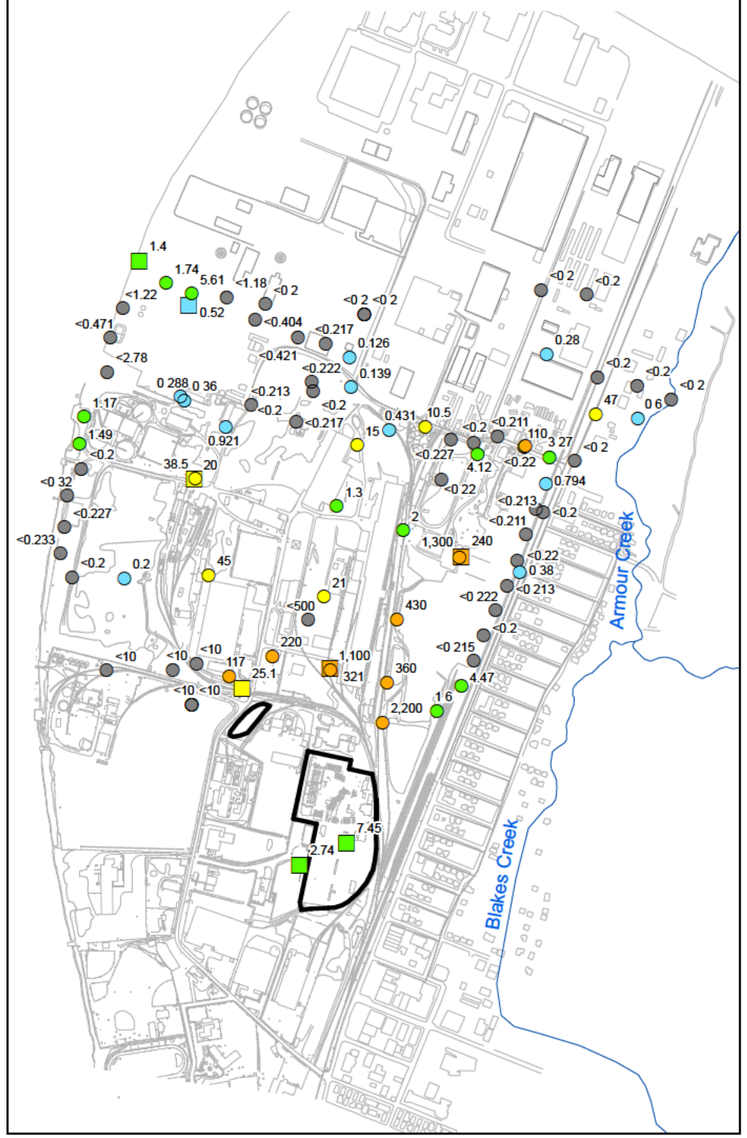
Kennesaw, GA | 18-May-2016

N:\Fike\Deliverables\GA 160213 CSM Update 2016\3 Appendices\Appendix B Historic Distribution Maps\mxd\FigB-2 13DMT Concentration Distribution.mxd; RMurray; 5/18/2016

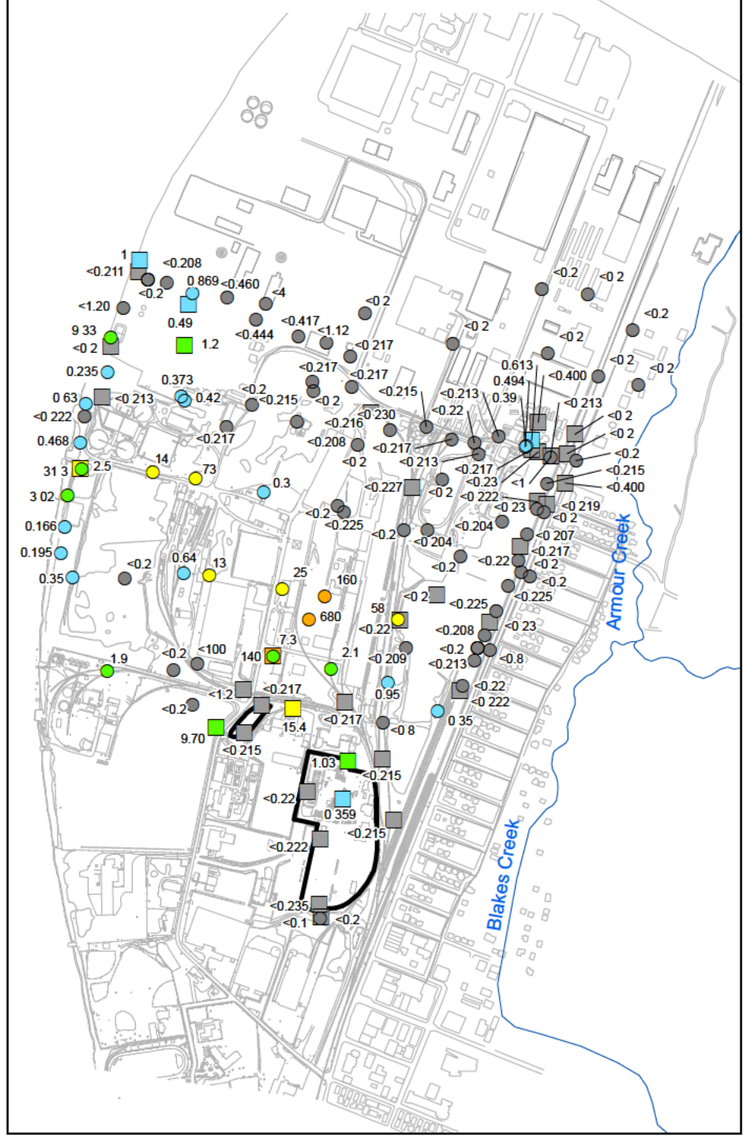
SHALLOW SAMPLING INTERVAL



INTERMEDIATE SAMPLING INTERVAL



DEEP SAMPLING INTERVAL



Concentration (ug/L):
- Not Detected
- 0 - 0.01 (PRG)
- 0.01 - 1
- 1 - 10
- 10 - 100
- 100 - 3,620

Sample Type
- DPT
- Monitoring Well

- Fike/Artel Site Boundary
- Streams
- Site Features

Note:
Data are the most current data for each location from investigation phases and routine monitoring data. The 2004-2005 pilot test data are not included.

0 500 1,000 2,000 3,000 Feet

Bis (2-Choroethyl) Ether Concentration Distribution

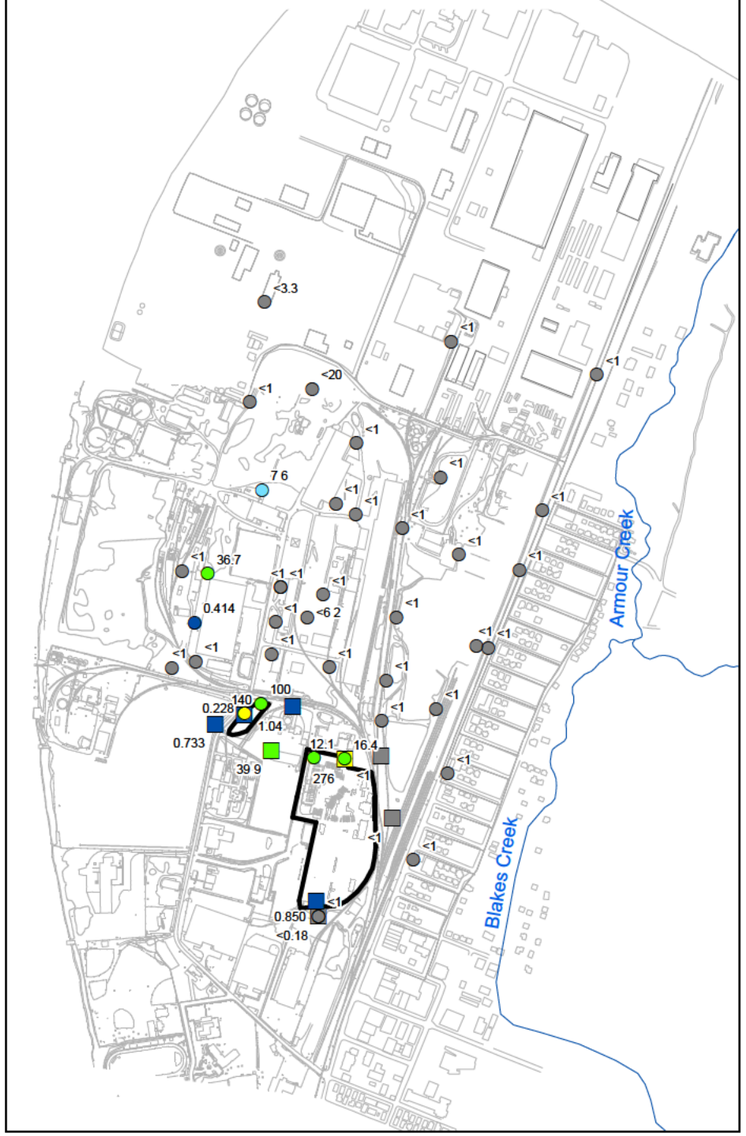
Fike/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure B-3

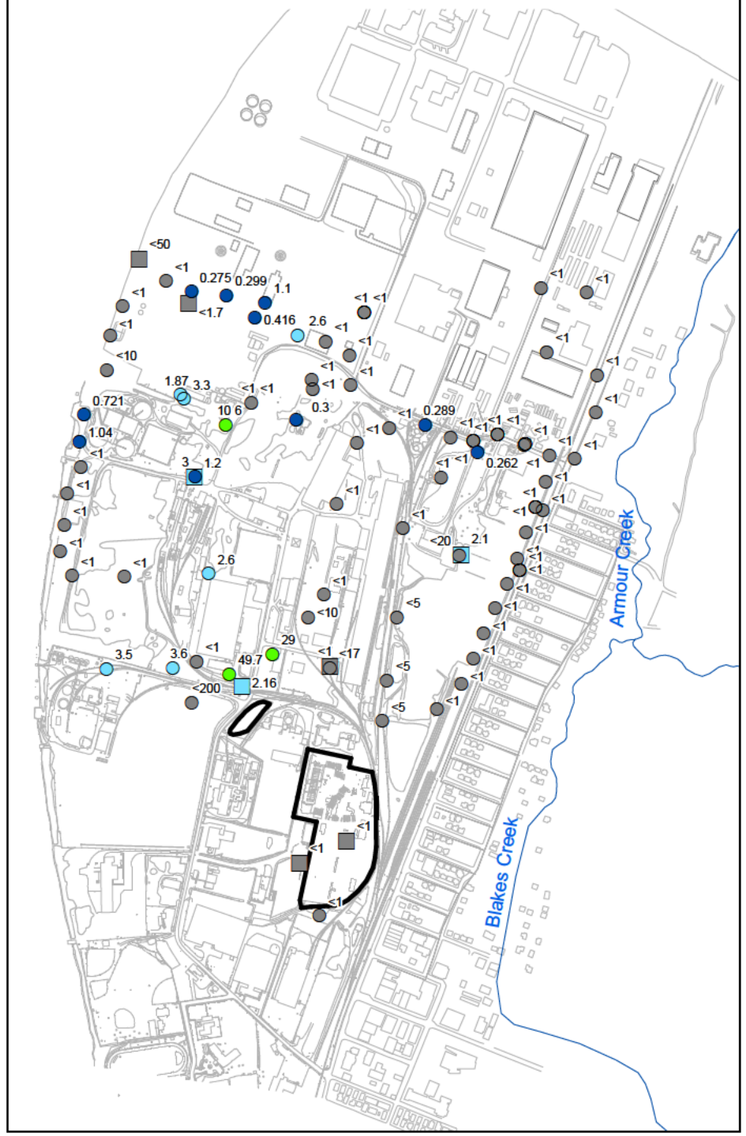
Kennesaw, GA | 18-May-2016

N:\Fike\Deliverables\GA\160213 CSM Update 2016\3 Appendices\Appendix B Historic Distribution Maps\mxd\FigB-3 BCEE Concentration Distribution.mxd; RMurray; 5/18/2016

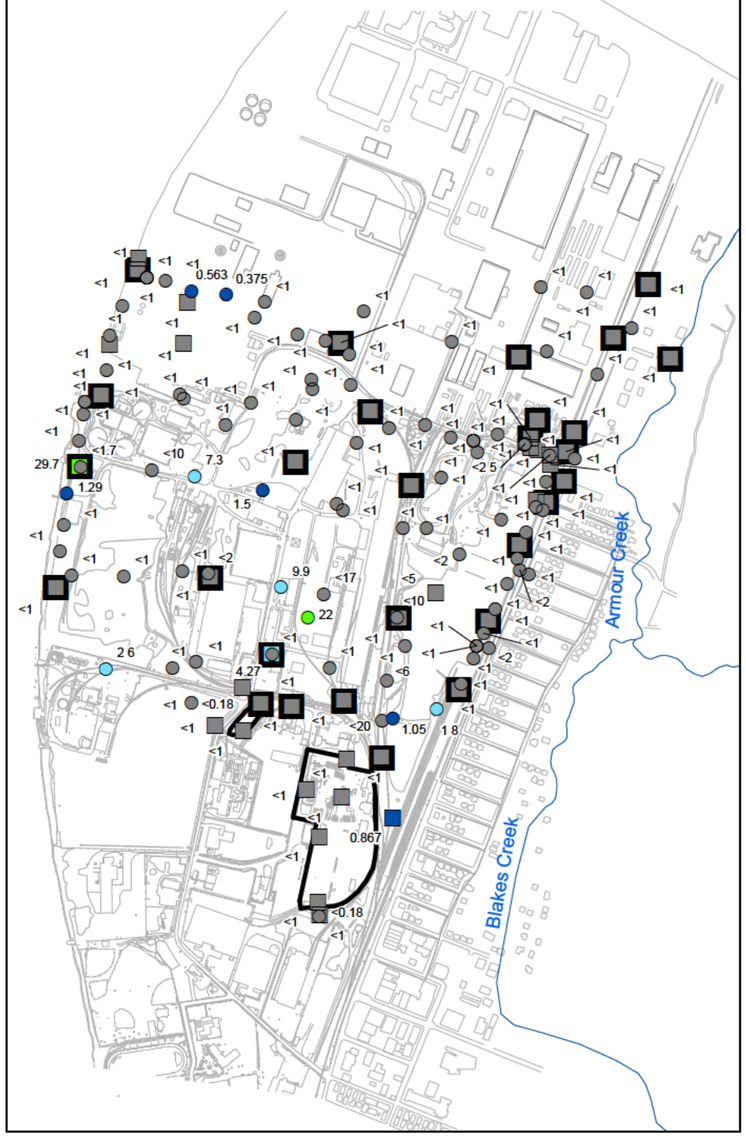
SHALLOW SAMPLING INTERVAL



INTERMEDIATE SAMPLING INTERVAL



DEEP SAMPLING INTERVAL



Concentration (ug/L):
- Not Detected
- 0 - 1.6 (PRG)
- 1.6 - 10
- 10 - 100
- 100 - 276

Sample Type
- Long-Term Monitoring Network
- DPT
- Monitoring Well

- Fike/Artel Site Boundary
- Streams
- Site Features

Note:
Data are the most current data for each location from investigation phases and routine monitoring data. The 2004-2005 pilot test data are not included.

0 500 1,000 2,000 3,000 Feet

1,2-Dichloropropane Concentration Distribution

Fike/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure B-4

Kennesaw, GA | 18-May-2016

N:\Fike\Deliverables\GA 160213 CSM Update 2016\3 Appendices\Appendix B Historic Distribution Maps\mxd\FigB-4 12DCP Concentration Distribution.mxd; RMurray; 5/18/2016

SHALLOW SAMPLING INTERVAL

INTERMEDIATE SAMPLING INTERVAL

DEEP SAMPLING INTERVAL

N

Armour Creek

Blakes Creek

Concentration (ug/L):
- Not Detected
- 0 - 0.4 (PRG)
- 0.4 - 10
- 10 - 100
- 100 - 1,000
- 1,000 - 4,120

Long-Term Monitoring Network

Sample Type
- DPT
- Monitoring Well

Fike/Artel Site Boundary
Streams
Site Features

Note:
Data are the most current data for each location from investigation phases and routine monitoring data. The 2004-2005 pilot test data are not included.

0 500 1,000 2,000 3,000 Feet

Benzene Concentration Distribution

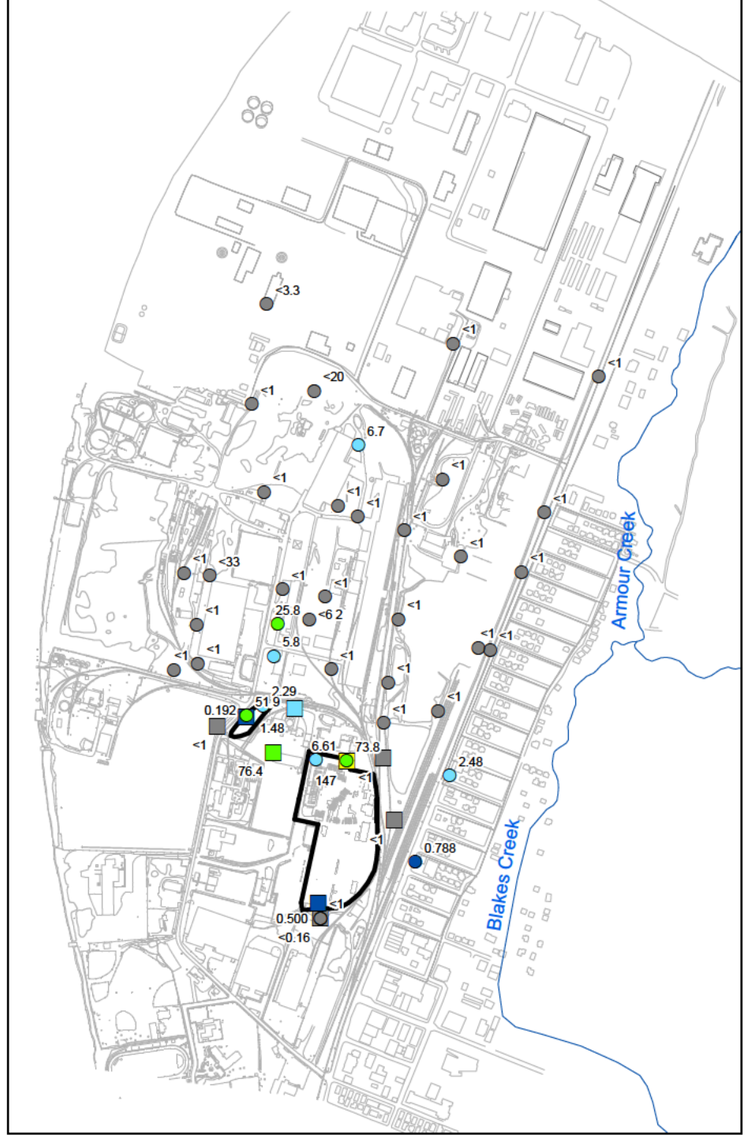
Fike/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure B-5

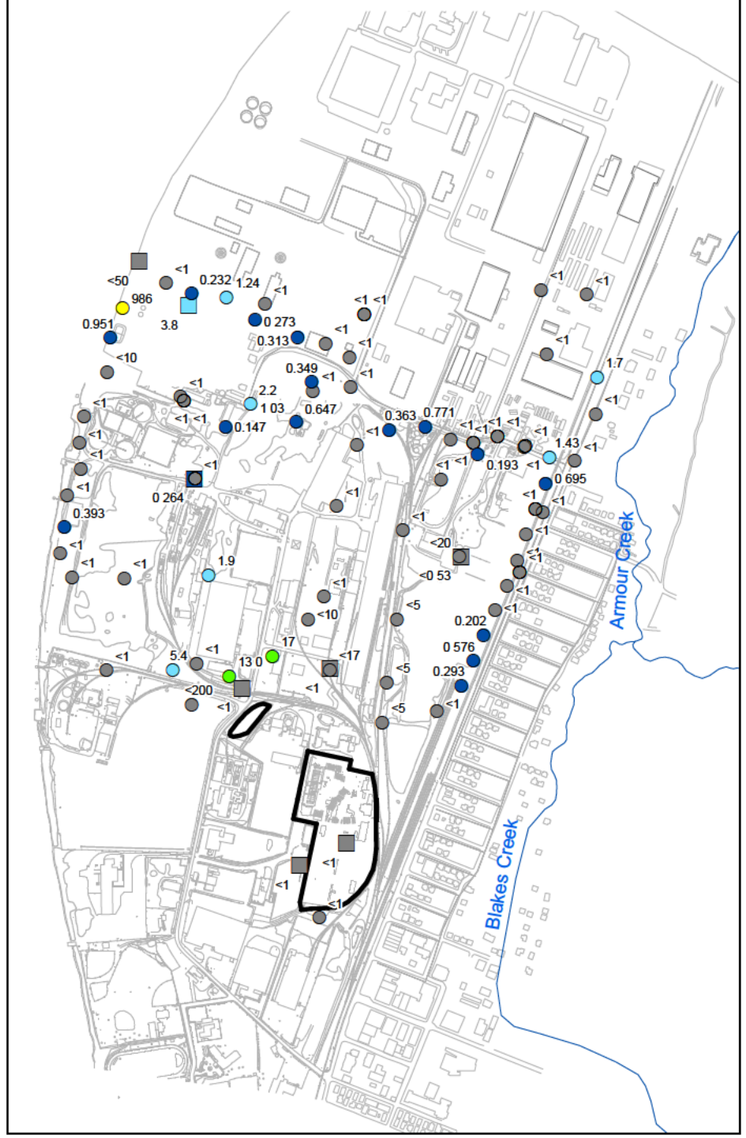
Kennesaw, GA | 18-May-2016

N:\Fike\Deliverables\GA160213 CSM Update 20163 Appendices\Appendix B Historic Distribution Maps\mxd\FigB-5 Benzene Concentration Distribution.mxd; RMurray; 5/18/2016

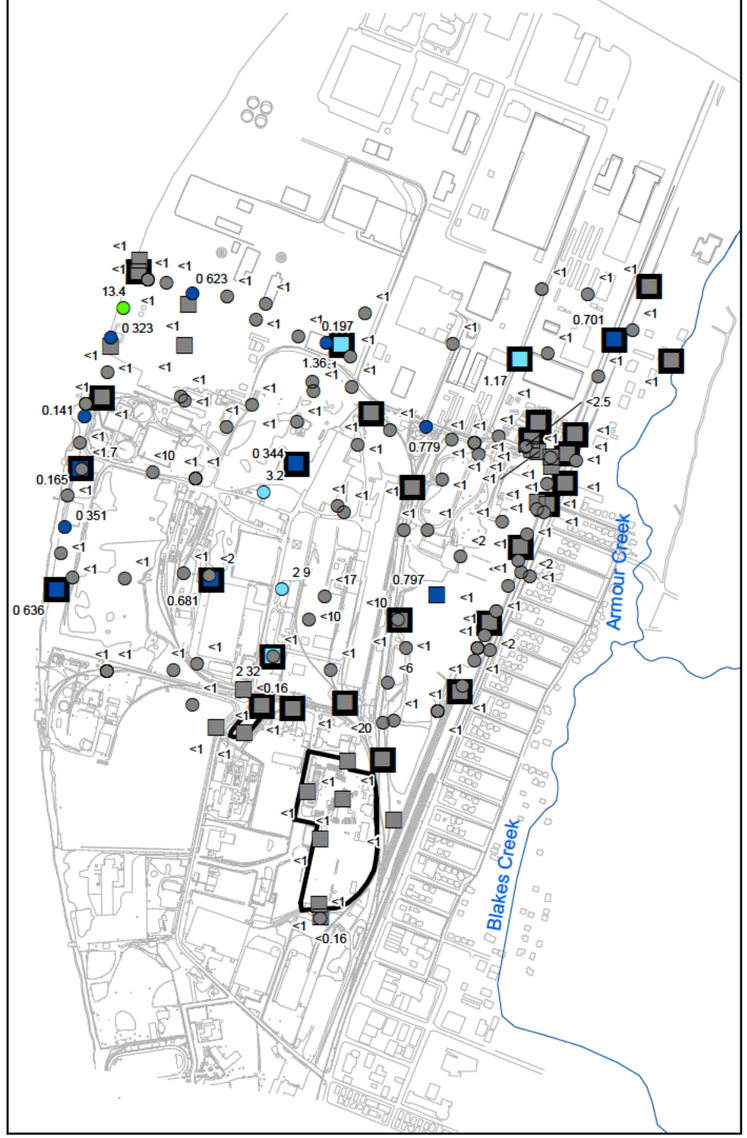
SHALLOW SAMPLING INTERVAL



INTERMEDIATE SAMPLING INTERVAL



DEEP SAMPLING INTERVAL



Concentration (ug/L):
- Not Detected
- 0 - 1.1 (PRG)
- 1.1 - 10
- 10 - 100
- 100 - 986

Long-Term Monitoring Network

Sample Type
- DPT
- Monitoring Well

- Fike/Artel Site Boundary
- Streams
- Site Features

Note:
Data are the most current data for each location from investigation phases and routine monitoring data. The 2004-2005 pilot test data are not included.

0 500 1,000 2,000 3,000 Feet

Chloroform Concentration Distribution

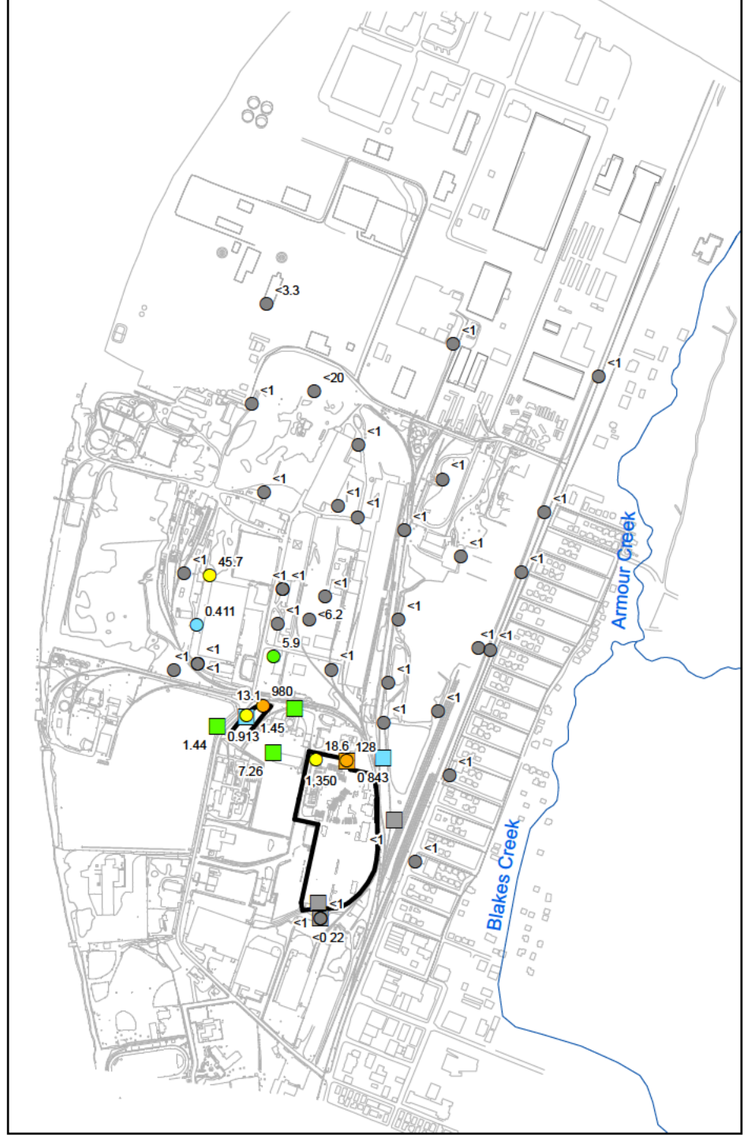
Fike/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Fike/Artel Site Trust | Figure B-6

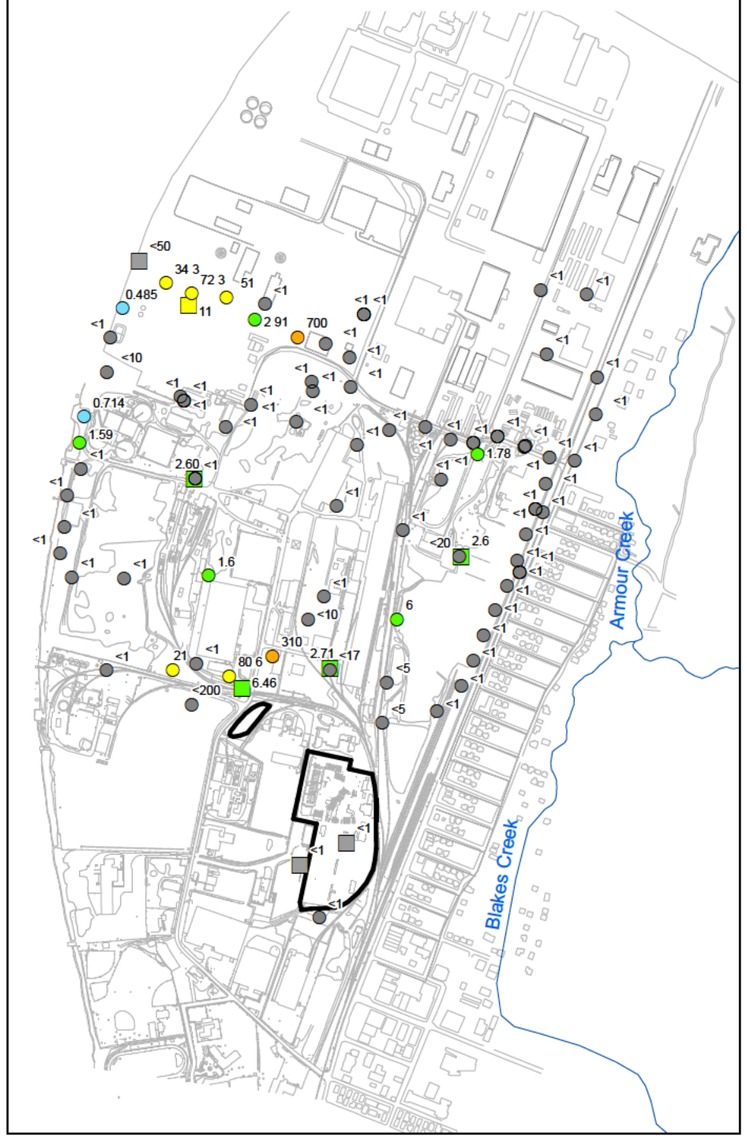
Kennesaw, GA | 18-May-2016

N:\Fike\Deliverables\GA.160213 CSM Update 2016\3 Appendices\Appendix B Historic Distribution Maps\mxd\FigB-6 CF Concentration Distribution.mxd; RMurray; 5/18/2016

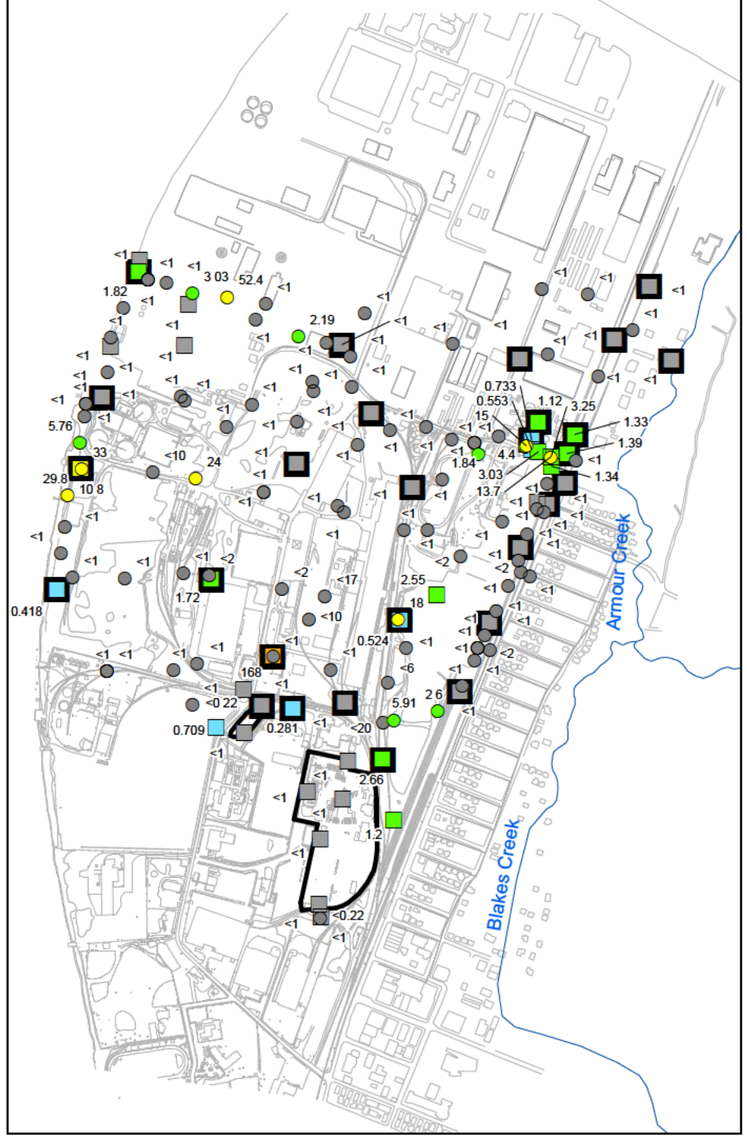
SHALLOW SAMPLING INTERVAL



INTERMEDIATE SAMPLING INTERVAL



DEEP SAMPLING INTERVAL



Concentration (ug/L):
- Not Detected
- 0 - 0.07 (PRG)
- 0.07 - 1
- 1 - 10
- 10 - 100
- 100 - 1,350

Sample Type
- Long-Term Monitoring Network
- DPT
- Monitoring Well

- Fike/Artel Site Boundary
- Streams
- Site Features

Note:
Data are the most current data for each location from investigation phases and routine monitoring data. The 2004-2005 pilot test data are not included.

0 500 1,000 2,000 3,000 Feet

Vinyl Cloride Concentration Distribution

Fike/Artel Superfund Site, Nitro, WV

Geosyntec consultants | Kennesaw, GA

Fike/Artel Site Trust | 18-May-2016

Figure **B-7**

N:\Fike\Deliverables\GA\160213 CSM Update 2016\3 Appendices\Appendix B Historic Distribution Maps\mxd\FigB-7 VC Concentration Distribution.mxd, RMurray, 5/18/2016

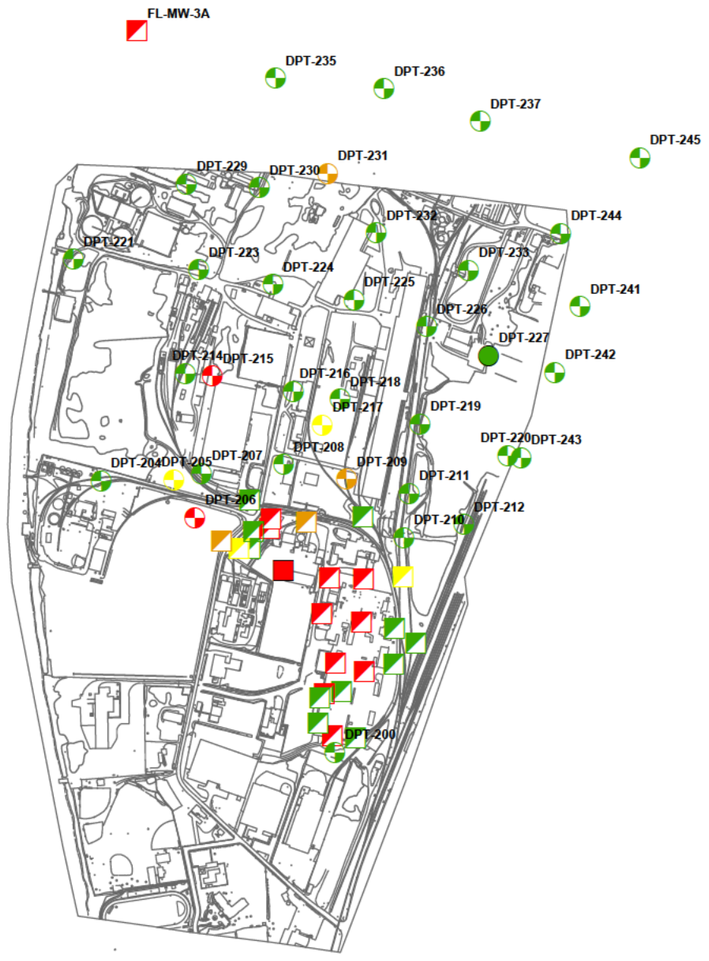
ATTACHMENT B

EXCERPTS FROM THE PRDI

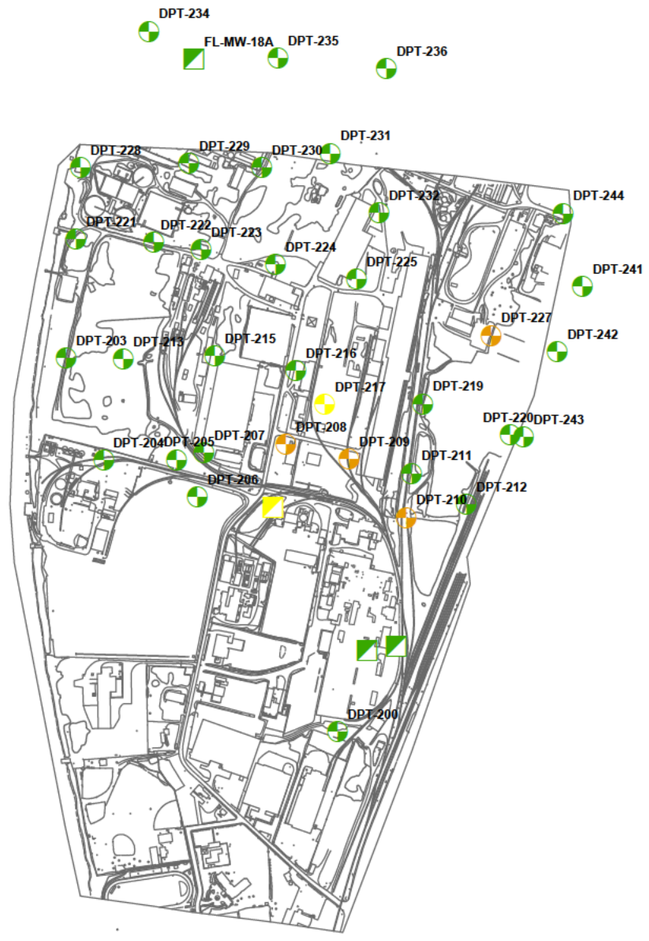
CARBON TETRACHLORIDE CONCENTRATION DISTRIBUTION

N

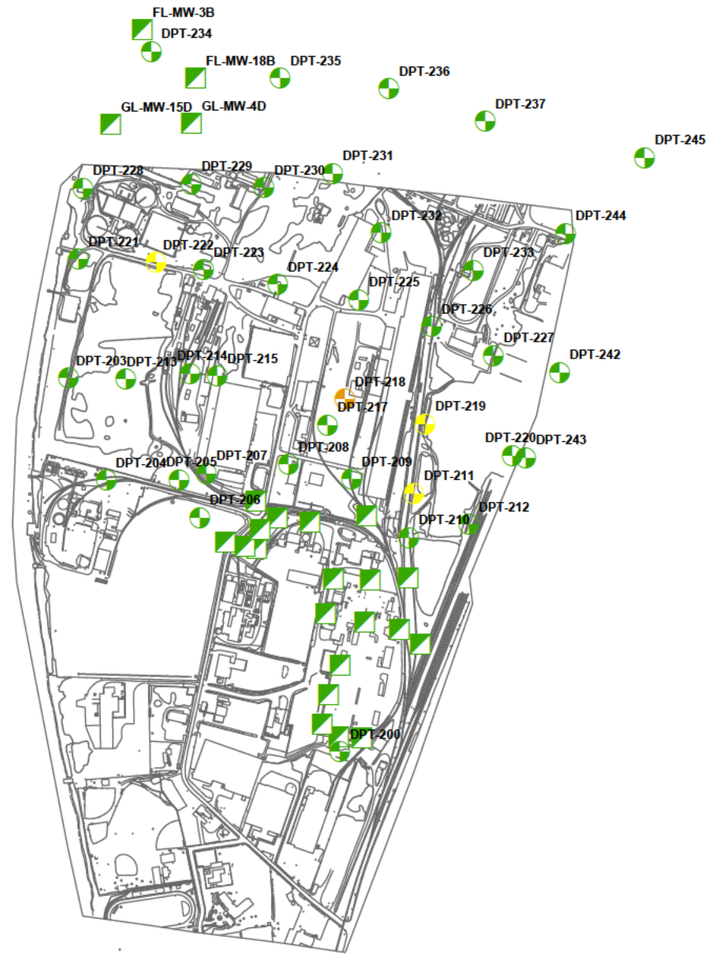
SHALLOW SAMPLING INTERVAL



INTERMEDIATE SAMPLING INTERVAL



DEEP SAMPLING INTERVAL



LEGEND

Concentration Ranges (µg/L):

- 0 - 0.162 (RBC)
- 0.162 - 0.23 (TCR)
- 0.23 - 5 (MCL)
- 5 - 10
- 10 - 20
- > 20

Sample and Result Type:

- DPT Detection
- DPT Non-Detect
- Monitoring Well Detection
- Monitoring Well Non-Detect
- Site Features

0 500 1,000 2,000 3,000 4,000 Feet

GeoSyntec Consultants
ATLANTA, GEORGIA

DATE:	11/07/03	SCALE:	AS NOTED ABOVE
PROJECT NO:	GS3220-920M	FIGURE NO:	14
DOCUMENT NO:	GA030591	FILE NO:	CT.MXD

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